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PROCEEDINGS

OF THE

FOURTH

SILVICULTURAL CONFERENCE

Dehra Dun, October 28th—November 4th, 1934

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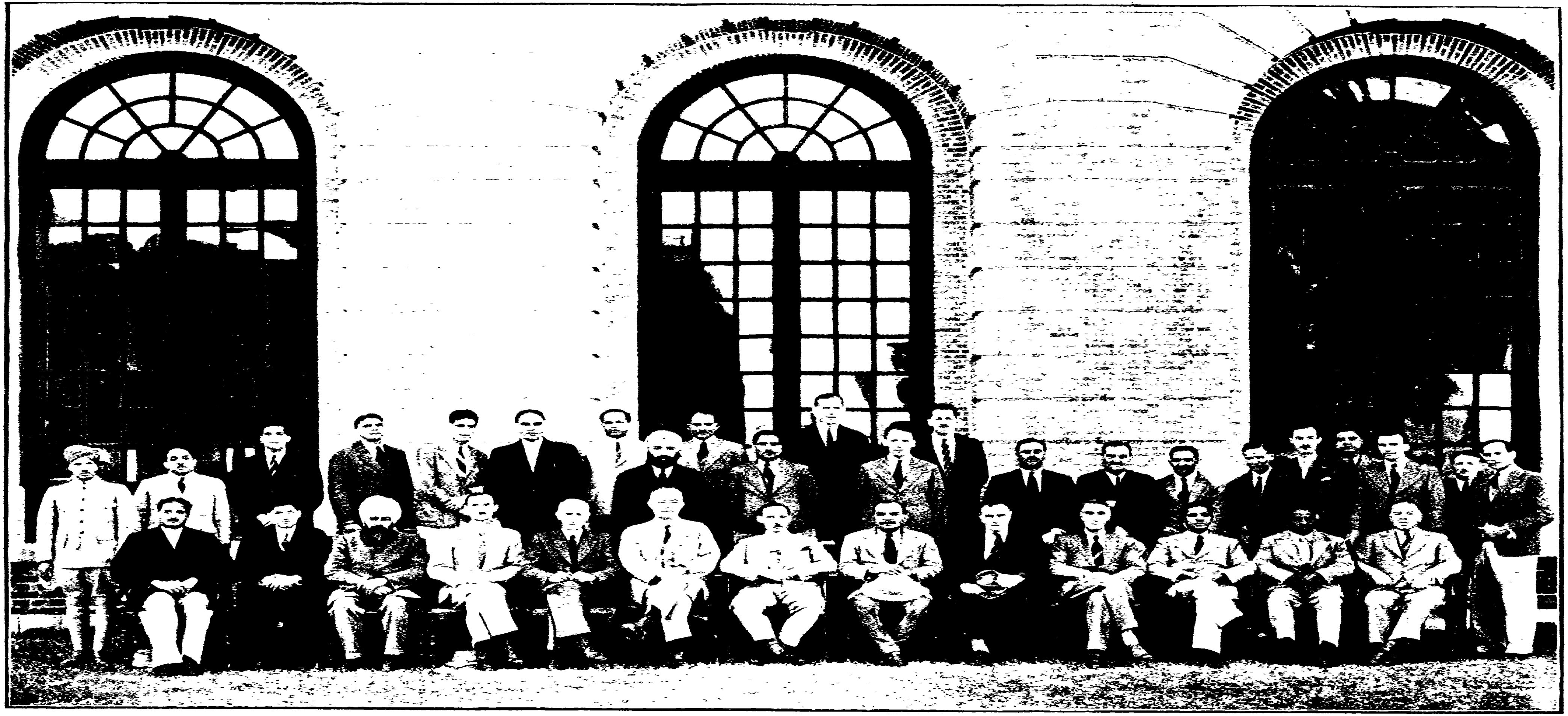

SITTING (from left to right)

Messrs. Allah Bakhsh, H. S. Pathania, Kartar Singh, S. H. Howard, H. L. Wright, C. E. L. Gilbert, C. G. Trevor, Nawab Hamid Yar Jang, E. O. Shebbeare, E. A. Smythies, B. V. Ramiengar, R. D. Pillai, A. R. Villar.

STANDING (from left to right)

Messrs. B. Nautiyal, M. A. Kakazai, R. C. Hoon, N. P. Mohan, P. N. Deogun, M. D. Chaturvedi, C. P. Jayawardnana, Partap Singh, C. S. Purkayastha, S. S. Negi, H. G. Champion, M. V. Laurie, H. F. Mooney, C. K. Homfray, E. A. Garland, E. O. Sampson, H. C. Watts, F. C. Osmaston, Nawab Zada Dianat Hussain, E. C. Mobbs, E. S. V. Burton, Sundar Singh.

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PROCEEDINGS OF THE FOURTH SILVICULTURAL CONFERENCE, DEHRA DUN, OCTOBER 29TH—NOVEMBER 4TH, 1934.

The *1st Conference* was held at Dehra Dun, from October 21st to 26th, *1918.*

The *2nd Conference* was held from January 10th to 14th, *1922,* also at Dehra Dun.

The *3rd Conference* was held from March 14th to 20th, *1929,* at New Forest, Dehra Dun, 36 Gazetted officers taking part, including one representative from an Indian State (Kashmir).

The *4th Conference* was held in the Board Room at the Forest Research Institute, Dehra Dun, 42 Gazetted officers taking part, including 6 representatives from 5 Indian States.

The following officers attended the Conference :—

Province or State.	Name.	Office.
Assam	1. C. S. Purkayastha ..	Botanical Officer.
	1(*a*). A. Das	Botanical Officer (on leave).
Bengal	2. E. O. Shebbeare ..	Conservator of Forests.
	3. C. K. Homfray ..	Silviculturist.
Bihar and Orissa ..	4. H. F. Mooney ..	Working Plans Officer.
	5. F. C. Osmaston	Forest Research Officer.
Bombay	6. C. E. L. Gilbert	Chief Conservator of Forests.
	7. E. A. Garland	Working Plans Officer.
Dangs	8. E. O. Sampson	Divisional Forest Officer.
Burma	9. A. R. Villar	Conservator of Forests.
Central Provinces ..	10. H. C. Watts	Silviculturist.
Chamba	11. Kartar Singh	Conservator of Forests.
Hyderabad (Deccan) ..	12. Hamid Yar Jung ..	Inspector General of Forests.
	13. Dianat Hussain	Sub-Assistant Conservator.
Kashmir	14. Harnam Singh	Silviculturist.
Madras	15. M. V. Laurie	Silviculturist.
Mysore ..	16. B. V. Ramiengar ..	Chief Conservator of Forests.
N. W. F. Province ..	17. H. L. Wright	Conservator of Forests.
Punjab	18. N. P. Mohan	Divisional Forest Officer.
	19. Pratap Singh	Silviculturist.
	20. E. S. V. Burton	Assistant Conservator of Forests.
	21. Sundar Singh	Divisional Forest Officer.

Saturday, November 3rd.—Chairman, Mr. C. G. Trevor.

10 A.M. .. .. 1. *Item 19.*—Revision of Code Form 16.

2. *Item 2.*—Filing system.

3. *Item 25.*—Fire records.

4. *Item 26.*—Date of next Conference.

5. *Item 21.*—Forests and Erosion.

6. Resolutions.

7. Publication of Proceedings.

8. Closing business.

2 P.M. .. .. Inspection of Economic Branch workshops.

Sunday, November 4th.—

11 A.M. .. .. Inspection of forests and taungya plantations in Saharanpur division.

OPENING ADDRESS

BY

Mr. C. G. Trevor, C.I.E., Inspector-General of Forests and President, Forest Research Institute, Dehra Dun.

Gentlemen,—On behalf of the Government of India and the Forest Research Institute it gives me very great pleasure to welcome you here this morning. This is the fourth Silvicultural Conference. The third was held in 1929 at which I had the honour to preside. At that conference, among the Indian States only the Government of Kashmir was represented, whereas this morning we have delegates not only from Kashmir but from Hyderabad, Mysore, Travancore and Chamba, so that our conference this year is fully representative not only of British India but of the whole Indian Empire, and it affords me great pleasure to welcome to-day the delegates from the Indian States.

Gentlemen, let us consider for a moment the object of our meeting here to-day. What is silviculture ? Silviculture, gentlemen, is the foundation of all forestry. Without silviculture, which is the knowledge of the growth of forest crops, there can be no forestry. You may have the most wonderful American lumbering methods to remove the trees which God gave you in past ages, but without the ability to grow trees and to grow them generation after generation, all these wonderful processes end in devastation as they have ended in devastation over a large portion of the globe. So that we who are concerned with the growth of trees have the direction of the practice in forest management and set the example to the generations that will come after us.

I should like to say a few words about the progress of forestry in India. I have over thirty years' service in this country, which I may say I have very much enjoyed, and during those thirty years the progress made in scientific forestry in this country has been remarkable. Those of you who belong to the rising generation of forest officers may not be aware of the striking progress which has taken place in Indian forestry during the last half century. It is only within the last thirty years that really scientific systems of forestry have been developed in this country for every important species, not only in one province, not only with conifers or teak ; from the top of the Himalayas to Cape Comorin, first class systems of forestry have been evolved in this country. Sometimes I hear it said that in order to learn forestry it is necessary to go to Germany, France, America, or some other country. Gentlemen, I have seen the forestry of most of the world and it is my considered opinion that the forestry which we have established in India is as good as you will find in any country. For a moment I should like to say a few words to my Indian colleagues ; gentlemen, the future of forestry in India lies in your hands. The Indian Forest Service has laid the foundation of forestry in India and has built up an organisation of which it may well be proud, and it will be for the Indian members of the Indian Forest Service and the members of the Class I and Class II Services which will eventually take the place of the Indian Forest Service to carry on this good work. There are no politics in forestry. We as foresters are merely concerned with the perpetuation of the forest and its improvement, and in your hands will lie the future of what I consider the very magnificent edifice which has been erected in this country during the last 100 years.

I next turn to the Forest Research Institute. What are the functions of this Institute ? I particularly welcome this large gathering because in some provinces the work of the Forest Research Institute is not appreciated as it might be. Many forest officers have never visited the Institute and are not fully acquainted with what we are endeavouring to accomplish here. Our object here is to assist forestry in India in every aspect of its work. We as Silviculturists are more particularly concerned with silviculture. The other branches of this Institute are concerned with other branches of scientific work connected with forestry, such as pathology, botany, economics—I would like you to look at the beautiful panelling in front of you for a moment to see what can be accomplished with Indian woods when they have been properly treated—and all these branches here are only too anxious to assist forestry in every province and every state in India to the best of their ability. We, gentlemen, are your servants ; it is for you to say what you want us to do, and unless you tell us what sort of investigations you want carried out and what your difficulties are, we are unable to carry out the work which we should do.

I would ask you, when after spending a week here and seeing the work of the Forest Research Institute, you go back to the provinces of India, to tell your colleagues what we are trying to do and how we may give assistance to each and every forest officer in India when he encounters difficulties in the course of his work. Co-operation is absolutely essential to success. We must, throughout India, in all branches of forest work, in all branches of learning, co-operate to one end, and this end is the benefit of Indian forestry.

Now for a few minutes I would like to review what has been accomplished since the last silvicultural conference of 1929. Action has been taken on the lines recommended in all the 22 resolutions and very good progress can be reported. The proceedings of the last silvicultural conference, which comprise a very substantial volume which I hope all of you have read, was certainly a valuable addition to the forest literature of the world. In giving effect to these resolutions, the Forest Research Institute has issued many publications such as those dealing with the Pure Teak Plantation (Bulletin 78), the Influence of Origin of Seed (Bulletin 41), the Multiple Yield Tables for deodar, Provisional Yield Table for *Quercus incana,* the Statistical Code for Silvicultural Research, and Experimental Manual for Silvicultural Research, and several other papers, and I am glad to say that co-operation between the Central Silviculturist and the provinces has been still further improved. Field apparatus has been further improved and its use extended. Field parties belonging to this Institute have joined in the work in the Punjab, United Provinces, Central Provinces, Madras, Bihar and Orissa, Bengal and the Andamans, and you will all remember that last year a very comprehensive tour was made through the *sal* forests in order to correlate the work of *sal* regeneration and management throughout the whole of India. In this tour representatives of all *sal* provinces partook. Despite financial difficulties the Punjab has appointed a Silviculturist and Coorg is just starting a research branch. It will be within your memory that in past conferences the question of the second rotation of teak in Malabar was discussed. It had been represented in official literature that in the second rotation of the pure teak plantation great deterioration had taken place and that there was considerable difficulty in re-establishing teak under such conditions. Well, I am glad to announce this morning that that problem no longer exists. By means of intensified soil working and the close study of the technique of planting, the plantations now being raised in the second rotation are, so far as can be ascertained, as good as their predecessors.

What are the outstanding problems of the future? The most important of all is the management and regeneration of tropical rain forest. Madras, Bengal, Burma, the Andamans are working on this problem and valuable research has been carried out in the Federated Malay States, with whom we should maintain close co-operation. The Andamans has evolved a system for the natural regeneration of forest crops which promises to be a great success but their forests are as much deciduous as they are evergreen. In Chittagong, Bengal has done very good work in regeneration of the *Dipterocarps* by notching germinating seed and Madras is also working on the regeneration of *Mesua* and *Hopea.* This is a problem which will require a great deal of work, but we must persevere until we have attained success. *Sal* regeneration remains a perennial source of difficulty but I think the United Provinces are prepared to say that progress has been made, and in the course of some years I hope that this problem will be completely solved. Other matters are the silviculture of simple mixtures in plantation and the management of mixed deciduous selection forest.

These, gentlemen, are the outstanding problems and as the time at our disposal is somewhat limited, this will conclude what I have to say to you this morning.

I accord you one and all a very hearty welcome to the Fourth Silvicultural Conference.

APPOINTMENT OF OFFICERS AND COMMITTEES.

The Inspector General of Forests nominated the following panel of chairmen, all of whom except the last-mentioned occupied the chair on different days :—

Messrs. C. E. L. Gilbert, E. O. Shebbeare, E. A. Smythies, S. H. Howard and H. L. Wright.

Mr. H. G. Champion was appointed Secretary with Messrs. Allah Baksh and M. V. Laurie as Assistant Secretaries.

Committees were then appointed as follows :—

ITEM 2. *Filing System.*—S. H. Howard (Chairman), F. C. Osmaston and E. C. Mobbs.

5. *Glossary of Technical Terms.*—C. G. Trevor (Chairman), E. O. Shebbeare, A. R. Villar, and S. H. Howard.

ITEM 6 (PT.). *Amendments to Silvicultural Experimental Manual.*—H. G. Champion (Chairman), H. C. Watts, C. K. Homfray, E. C. Mobbs, E. A. Garland, F. C. Osmaston, Partap Singh, M. V. Laurie and C. S. Purkayastha (*i.e.*, all Provincial Silviculturists except Burma), Harnam Singh (Kashmir), P. N. Deogun and S. S. Negi.

ITEM 9. *Regeneration of evergreen forest.*—M. V. Laurie (Chairman), B. V. Ramiengar, R. Dhanukoti Pillai, H. G. Champion, C. K. Homfray, and C. S. Purkayastha.

ITEM 11. *Amendments to the Statistical Code.*—H. G. Champion (Chairman), M. D. Chaturvedi, H. C. Watts, Harnam Singh, M. A. Kakazai, and S. S. Negi.

ITEM 11 (c). *Statistical Research in Irregular Crops.*—E. A. Smythies (Chairman), C. K. Homfray, M. V. Laurie and E. C. Mobbs.

ITEM 19. *Revision of Code Forms 16 and 16-A.*—E. A. Smythies.

ITEM 25. *Record of Fire Protection results, Code Form 14.*—E. A. Smythies.

RESOLUTIONS.—E. O. Shebbeare, S. H. Howard and H. F. Mooney.

PROCEDURE.

The same procedure was followed as at the 1929 Conference. Each Item introduced by a delegate who (with rare exceptions) had been asked beforehand to undertake the task of reviewing the papers submitted ; where a committee was appointed, this delegate presided over its meetings and presented the report. There was again no question of divisions necessitating allotment of voting powers, draft resolutions being revised when necessary to ensure general acceptance in their final form.

Meetings were held at 10 A.M. and 2 P.M. daily with an interval for lunch which was served in the Library.

DATE OF NEXT CONFERENCE.

This question was discussed before the resolutions were passed, and the Inspector General of Forests, presiding, directed that it should be recorded that it was the general feeling of the conference that the Silvicultural Conference should be held at least every five years.

In the course of the debate, Messrs. SHEBBEARE, HOWARD, OSMASTON and MOBBS stressed the value of the past conferences to research in the provinces, both as resulting in an improvement in research methods and in a general stimulation of interest in the work. They generally favoured meetings at shorter intervals if possible. Mr. CHAMPION referred to their value to the Central Silviculturist in that they enable him to learn in a way impossible from circular enquiries, just what the really important problems are and so to direct his work into the most useful channels. The 1929 Conference had given him five years work and the present one had resulted in a similar formidable programme.

The question of the time of the year most convenient for holding the conference was again raised and it seemed generally agreed that certain objections notwithstanding, October was the best month, and definitely preferable to March (the date of the 1929 Conference).

PUBLICATION OF PROCEEDINGS.

The Secretary proposed that a local committee be appointed to edit the proceedings of the Conference for publication, but was requested to accept this work and given full authority to deal with the papers and debates to bring them into suitable form for the purpose. [This has been done under difficulties owing to a period of foreign service immediately after the Conference—H. G. C.]

INSPECTIONS.

(1) THE EXPERIMENTAL PLANTATIONS AT THE RESEARCH INSTITUTE.

Tuesday, October 30th, 2 to 3-30 p.m.

The delegates motored to *sal* Compartment 1 of the plantations, inspecting the first five items listed below. They then motored to Teak Compartment 5 and saw remainder of the items. The Central Silviculturist explained the points of interest for each item.

1. Replicated thinning experiment in *chir* pine 1925 *taungya* line sowings, comparing C-grade ordinary thinning, D-grade, and Free thinning, each with six replications in plots of one-eighth of an acre each.
2. Replicated experiment on the effect of the root competition of a *sal* coppice underwood on the growth of a *sal* overwood from 1924 *taungya* line sowings. There were 4 replications on rectangular plots 24 by 48 ft.
3. Cover crops with *sal taungya*—*Indigofera tinctoria, I. endecaphylla, I. hirsuta, I. galegioides, Leucaena glauca, Tephrosia candida*, and *T. purpurea.*
4. Root systems of *sal* and *Tephrosia candida*, the latter grown as a cover crop between the *sa*
5. Different seed origins for *sal*, Haldwani, Gorakhpur (large seeded and small seeded), Hoshiarpur, Lansdowne, Siwalik, Bihar, Central Provinces and local. Frost damage was very apparent throughout.
6. Root systems of *Imperata arundinacea* and teak.
7. Root systems of *Saccharum spontaneum* and teak.
8. *Gmelina* plantations showing damage by insects, frost and fungus (species as yet unidentified).
9. Frost damage to teak of all ages (earliest 1924), the cover crop of *Tephrosia* having been itself exterminated.
10. *Dalbergia latifolia* plantations from 1925—1928 attacked by unidentified Ascomycete fungus.
11. Soil pit in 1926 *Gmelina* plantation showing absence of differentiation of horizons, due to past cultivation, with some trace of hardening at the level reached by the ploughing. (The latter has been shown often to result in a bend in the roots of seedlings searching an easy way through—*H. G. C.*). Demonstration by Dr. Puri.

(2) THE SILVICULTURAL EXPERIMENTAL GARDEN AT THE RESEARCH INSTITUTE.

Thursday, November 1st, 2 to 3-15 p.m.

The delegates walked down the central road of the Experimental garden, the Central Silviculturist explaining the chief features of a selection of the experiments in progress. The following experiments were seen and dis- l :—

C. 1. *Araucaria cunninghami* plantation (1932).

C. 16. *Casuarina* root nodules. Mr. Blake's experiment to demonstrate the necessity of infection of the roots by the appropriate organism for satisfactory development.

C. 15. Nurseries.

Effect of raising the level of beds (*Acacia*

Effect of different types of shade (*Adina*).

C. 2.	1932 Storage of teak stumps before planting. 1932 Effect on growth of the number of plants per patch for teak. 1932 Stump planting of *Aleurites fordii*, survival 42 per cent. 1932 Comparison of sowings, entire transplants and stumps of *Bombax* in favour of stumps. 1932-33 Entire winter planting of *Kydia* on successive dates, November to March, showing good survival and equal height throughout. 1932 Line sowings of *Terminalia chebula*.
C. 3.	1933-34 Weekly winter entire planting of *Bombax* showing good survival throughout. 1933 Stump planted *Ougeinia*, 76 per cent. survival. 1933 Storage of teak stumps before planting. 1929 *Gmelina* shewing progress of fungus disease. 1931 Effect of injury to teak stumps, survival 100 per cent. throughout. 1931 Forest and nursery grown stumps of *Dalbergia sissoo*, survival 56 and 90 per cent. respectively.
C. 14.	Artificial regeneration under shade :— 1930 *Anogeissus latifolia* winter planting, survival 70 per cent. 1930 Early planting of teak stumps. 1932 *Phoebe lanceolata* rains stumps, survival 98 per cent.
C. 13.	1934 Short term teak seed origin experiment. 1934 Root sections of *Dalbergia sissoo*, 100 per cent. survival. 1934 Winter stump planting of *Stereospermum, tetranda* and *Cedrela toona*, all successful. 1931 Winter planting of *Hymenodictyon*, survival 75 per cent.
C. 4.	1934 Winter and early planting of teak stumps. 1927 Stumping experiments. Effect of delayed planting in *Kydia calycina* (very slight). Effect of diameter of stump for *Grewia tiliaefolia* (marked), and *Bischofia* (nil).
C. 5.	Short term experiment for 6 teak seed origins (1933) arranged ABCDEFFED......
C. 12.	Lac races of *Schleichera* and *Butea*.
C. 11.	Bamboo plantations for study of causes of congestion in clumps.
C. 5, 6, 7.	Teak seed origin plots, 1933 and 1934.
C. 9.	Eradication of *Imperata* by digging and sowing up with mixed leguminous cover crop, and the marked effect on the growth of stagnating *Adina*.
C. 8, 9.	Plots of different seed origin of *Terminalia tomentosa* and *catechu*.

(3) FORESTS AND TAUNGYA PLANTATIONS IN DEHRA

1-30 p.m. to 6

The Conference left New Forest in two buses at 1-30 P.M. and drove out 14 miles to Lachiwala. The first stop was to see two soil pits, one in a bamboo plantation and one under *sal* forest, in which the features exhibited by the soil profiles were explained by Dr. Puri. The profuse natural regeneration of teak from a group of planted trees was seen and Mr. Smythies (Conservator of the Circle including Dehra Dun division) explained the main features of the working plan and its relation to the general forest situation in the United Provinces. The Divisional Forest Officer, Mr. J. E. C. Turner, explained his system of compartment signboards and the visitors were also interested in the road signs The proposed halts were indicated by special notices and the objects of silvicultural interest at each are described in the appended note. It was however unfortunately necessary to pass by halts 1 and 6 as the buses could not travel as fast as the cars for which the programme had been designed ; the essential points were however seen from the road. The round finished about 5 o'clock at Lachiwala Forest Rest House where Mr. and Mrs. Turner entertained the party to tea, many other visitors from Dehra Dun being also present.

* * * * * * * *

Note by J. E. C. Turner, Divisional Forest Officer.

Halt No. 1 (10 minutes).

Taungya operations in the Miscellaneous Working Circle Lachiwala block, compartment 2-XXX. In this connexion, paragraph 199 of the Working Plan reads as follows :—

> " No satisfactory system has yet been applied in this division of regenerating miscellaneous forest." And it goes on to say that these " forests of the eastern Dun appear to offer ideal conditions for artificial work ".

Since regular plantations in this type of forest cost approximately Rs. 40 per acre, and money nowadays is not easy to obtain, it is hoped to solve the difficulty by regenerating these forests through *taungya* and endeavouring to raise more valuable forests at minimum expenditure, and this is the object aimed at. The Working Plan does not mention *taungya* which has since been introduced by the territorial staff.

The crop which has been felled consisted mainly of *kokat* (inferior species) with a little *Shorea robusta, Terminalia tomentosa, Cedrela toona, Dalbergia sissoo, Acacia catechu,* and *Bombax malabaricum* ; only *khair* trees were left standing in accordance with orders, but now it is thought that it would be better to cut these also and the matter has been represented to the Conservator. The felling was carried out during the winter and early spring, a *taungya* village was established in April, and a *kharif* crop sown as soon as the land was ploughed. Sowings of *Shorea robusta, Terminalia tomentosa, Acacia catechu* and *Dalbergia sissoo* will be done in June 1935.

History of this Compartment.

Year.	*Operations, if any, carried out.*
1903-23	No fellings.
1923-24	Sal Working Circle. P. B. Intermediate, thinnings.
1924-25	Subsidiary cultural operations.
1933-34	Fellings followed by *taungya* over 30 acres.
1934-35	Another 30 acres under fellings to be followed by *taungya*.

Halt No. 2 (15 minutes).

Lachiwala Block Compartment No. 1.—This area having been under a ten years' village lease from July 1, 1921, to June 30, 1931, was resumed by the Forest Department, and *taungya* operations were commenced in 1932. Sowings of forest species were carried out over an area of 46 acres in June, 1933 ; the plants which are in lines 15 feet apart, are thus now 16 months' old. The species put down are *Shorea robusta, Terminalia tomentosa, Ougeinia dalbergioides, Acacia catechu, Dalbergia sissoo, Terminalia belerica,* etc.

In 1934 experimental sowings of mulberry (*Morus alba*) were done and root and shoot cuttings have also been tried ; both seed and cuttings were obtained from the Punjab plantations.

This particular compartment has not been allotted to any Working Circle in the Working Plan. The object is to re-stock it with the most valuable species which we can successfully raise.

In this *taungya* village we have established a Co-operative Society under the District Co-operative Bank. This is first forest Co-operative Society to be formed in the United Provinces.

History of the Compartment.

Year.	*Operations, if any, carried out.*
1903-21	No fellings.
1921-31	Remained under cultivation as a forest village leased free of rent in return for labour.
1932-33	Establishment of *taungya.* 69 acres of land distributed, out of which 46 acres were sown up with *sal, sain, khair, sissoo,* etc.
1933-34	23 acres more brought under *taungya.*

Professional Graziers' Working Circle, Banbaha block, Compart. 4 (Pt.).

Halt No. 3 (20 minutes). *Taungya* operations have been undertaken in this Working Circle with the object of producing a large quantity of leaf and grass fodder for the ever increasing needs of the dairy industry ; at the same time to grow a proportion (about one-third) of valuable commercial species like *Acacia catechu,* and *Dalbergia sissoo.* An interesting feature of this area, which was practically treeless before, is that the species for lopping have been sown mixed in the lines which are 15 feet apart. Sowings of forest species were done in June, 1933, so that the excellent growth now to be seen is but 16 months' old. The lopping species are :—*Albizzia procera, Ougeinia dalbergioides, Bauhinia* spp., *Bombax malabaricum, Moringa pterygosperma, Stereospermum suaveolens* and *Terminalia belerica.*

The area is 32 acres and being low lying is subject to frost damage, as also to damage by deer. This being so, it is not proposed to carry out thinnings till about the third year. Some mulberry root and shoot cuttings were obtained from the Punjab plantations and put down by way of experiment.

History of the Compartment.

Year.	
1903-23	*Shisham* selection working circle fellings.
1927-28	Grazing working circle fellings, *e.g.,* felling of *sissoo, tun, Jaman* and other saleable trees.
1932-33	32 acres distributed for *taungya* cultivation and forest species sown in June 1933.

Sal Conversion Working Circle, Eastern Felling Series, Periodic Block I, Jhabrawala block, Sub-compt. 8a.

Halt No. 4 (15 minutes). —This area of 68 acres was marked for regeneration fellings in 1933-34 and will be felled during 1934-35. The record of markings for one plot is attached and shows the classification of trees for purposes of sale. The cost of such markings is approximately five annas per acre. The heights of ten per cent. of the trees over 16″ diameter marked for felling are actually measured by the Marking Officer to keep his eye in, the heights of the rest being judged by eye. All marked trees over 12 inches diameter are lopped (to minimize damage in felling) as soon as the markings have been approved ; the average cost of lopping is one anna nine pies per tree. The outturn is calculated according to a volume table and then the estimated price is fixed by the Divisional Officer.

outturn of sawn *sal* timber is 8,188 c. ft. and the price obtained at the annual auctions held last month (September) was Rs. 12,610, *i.e.*, Re. 1-8-7.5 per c. ft. The estimated outturn per acre is 120.4 c. ft. and the price obtained per acre is Rs. 185-7-0.

In this Working Circle the objects of management are :—

(1) Gradually to convert the *sal* forests allotted to the Working Circle to uniformity.

(2) To equalise the distribution of the age classes, *i.e.*, to obtain the normal forest.

(3) Consistent with the above objects to obtain the greatest possible sustained yield without overfelling.

A copy of the Marking Rules is attached.

History of the Compartment.

Year.	
1917-18	Improvement fellings.
1923-24	Heavy P. B. Intermediate fellings.
1924-25	Departmental cultural operations.
1931-32	Climber cutting.
1933-34	Marked as a P. B. I. (regeneration area) for felling in 1934-35.

Rules for Periodic Block I of the Sal Conversion Working Circle.

The object of fellings in P. B. I. is to remove as much of the overwood as possible in the interests of the advance growth already present on the ground, and to do as little damage as possible to this advance growth.

The following marking rules are therefore made :—

(*a*) All overwood standing over groups of *sal* advance growth of any size up to 12″ diameter will be marked

(*b*) Trees which in being felled are likely to damage *good* advance growth fit for retention are to be lopped before the felling is carried out and such trees will be indicated by the letter L.

(*c*) As regards poles below 12″ diameter the following instructions should be very carefully followed :—

(*i*) Where such poles are in groups even over a small area, they should be definitely retained to avoid an unnecessary sacrifice.

(*ii*) Where such poles are solitary and are interfering with the general uniformity of the standing crop they should be marked for felling.

(*d*) In groups of larger but not mature trees with insufficient *sal* advance growth beneath them a light and cautious thinning will be done *only where*

In such groups the *kokat* middle storey must always be retained to keep down grass and minimize fire risk.

(*e*) Where groups of mature and over mature trees are found with insufficient *sal* advance growth under them, such trees will normally be removed if they are deteriorating ; but care should be taken not to create blanks of more than one acre (about five *bighas*). A *kokat* middle storey, where present, should always be kept in such cases.

NOTE.—The presence of a *kokat* middle storey will enable the marking officer to mark a larger number of such deteriorating mature and overmature trees without fear of creating a blank.

(*f*) Small patches of *kokat* are to be felled over lightly and any large trees which are saleable and are silviculturally fit for removal are to be marked.

(*g*) Forests on broken ground on the sides of *kholas*, on the edges of grassy *tappars* and on low-lying ground liable to frost are to be marked with caution.

GREEN AND DRY TREES TO BE SOLD BY LUMP SUM.

Range—**Lachiwala**, Working Circle—**Sal Conversion**, P. B.—**I**, Block—**Jhabra wala**, Compartment—**8A**, **Plot I**, Area—**34 acres**.

Nearest Railway Station—**Kansrao**.

Nearest Road—**Kansrao-Jhabrawala**.

Name of purchaser—

Price realized—

Security money—

Lot No.	Species.	Diameter in inches.													Total.	Remarks.
		0″—8″.	8″—12″.	12″—16″.			16″—20″.			20″—24″.			Over 24″.				
				Sound.	Hollow.		Sound.	Hollow.		Sound.	Hollow.		Sound.	Hollow.			
					Fit.	Unfit.		Fit.	Unfit.		Fit.	Unfit.		Fit.	Unfit.		
29	**Sal green**	5	21	91	79	3	37	134	4	8	47	1	..	15	1	446	Felled and fallen firewood is not included in the sale of this lot. Only sawn and round timber may be exported.
	Sal dry	1	4	..	1	..	..	1	..	..	..	..	..	..	..	7	
	Sandan	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	
	Kokat dry	2	5	..	4	2	..	1	2	..	..	..	..	..	..	16	

Period of work and export—From October 1, 1934, to March 31, 1935.

Halt No. 5 (10 minutes).

Sal Conversion Working Circle, Eastern Felling Series, P. B. I., Balindawala block, Sub-compt. 12c.—The area is 67 acres and was felled in 1932-33. The actual outturn in sawn *sal* timber was 21,805 c. ft., or 325 ft. per acre. The price obtained was Rs. 18,525 or Rs. 276-8-0 per acre. The price obtained per c. ft. for sawn timber was Re. 0-13-7.

In addition to the sawn timber noted above, the purchasers extracted 10,158 c. ft. (stacked) of firewood. The working plan, in paragraph 162, prescribes one year for recuperation, and cultural operations will be carried out during 1934-35. During this work mathematical uniformity is not aimed at but rather uniformity by groups, so that any stem that can fit into the future crop should be retained. Inferior species will be lopped or cut back where they are suppressing *sal* but will be retained where there is no *sal*. Damaged *sal* stems will be cut back. Material resulting from such cultural operations will be sold in order that the area may be left free of slash.

History of the Compartment.

Year.	
1909-10	Improvement fellings under Milward's Plan.
1925-26	Heavy P. B. Intermediate fellings under Bhola's Plan.
1926-27	Departmental cultural operations consisting of cutting back of badly grown and suppressed *sal* advance growth and probably cutting of a good deal of *kokat* in the middle storey.
1931-32	Climber cutting.
1932-33	P. B. I. (Regeneration) Fellings.
1933-34	Recuperation period.
1934-35	(Cultural operations will be carried out).

Halt No. 6 (20 minutes).

Sal Conversion Working Circle, Eastern Felling Series, Periodic Block I, Phandowala block, Sub-compt. 9b.—This sub-compartment of 165 acres was felled in 1931-32 and left for recuperation during 1932-33. Cultural operations have been carried out in 1933-34. The total actual outturn in sawn *sal* timber was 68,381 c. ft. or 414 c. ft. per acre. The price obtained was Rs. 44,375 or Rs. 269 per acre.

The price obtained per c. ft. for sawn timber was Re. 0-10-6.

In addition to the sawn timber noted above the purchasers extracted 13,669 c. ft. (stacked) of firewood and 12,250 c. ft. of round *sal* timber.

In the cultural operations care is taken to cut out or lop miscellaneous species only where there is interference with *sal*. *Sal* saplings damaged during fellings and very misshapen saplings were cut back. The produce resulting from these cultural operations was sold for Rs. 90.

In this sub-compartment the Marking Officer was overcautious which was perhaps to be expected as this area was the first to be marked under the new Working Plan. This excessive caution resulted, as is now clear, in the unnecessary reservation of seed bearers. Silviculturally, it will be better to take these trees out as they are really serving no practical purpose and, indeed, are doing harm by causing root-competition to the detriment of *sal* regeneration. Accordingly, it is proposed to fell these trees after careful lopping of their crowns.

History of the Compartment.

Year.	
1905-06	Improvement Fellings under Milward's Plan.
1922-31	Was put down as one of the P. B. Intermediate areas in Bhola's plan but no fellings were done.
1930-31	Climber cutting.
1931-32	P. B. I. (Regeneration) fellings.
1932-33	Slash sold and exported.
1933-34	Subsidiary cultural operations carried out on daily labour under proper supervision and followed by sale of produce of these operations.

Summary of the History of the Management of Dehra Dun Division for over a century and a short resumé of the current Working Plan.

1. **From 1814**, the date of British occupation, to 1871, irregular uncontrolled fellings occurred. In the latter year organization commenced and fellings were checked. Gradually matters improved and the felling of *sal* curtailed and eventually the first Working Plan was introduced in 1883.

2. **Fernandez's working plan**, 1883-1903.—This prescribed the selection system for certain *sal* forests and Improvement Fellings for the remainder. Subsequently, the whole of the *sal* forests were brought under Improvement Fellings.

3. **Milward's Working Plan**, 1903 to 1922-23.—Improvement Fellings were prescribed for all the *sal* forests, except those in Thano and Barkot ranges where the Selection System was preferred. In 1910 Troup's Working Plan for the Thano *sal* forests laid down experimental regeneration fellings which have been very successful. Some *sal* forests near Dehra Dun were worked under coppice with standards.

4. **Bhola's Working Plan**, 1923-24 to 1930-31.—The treatment prescribed for the *sal* forests was conversion to uniform high forest with regeneration by compartments under a shelterwood. The miscellaneous forests were treated under coppice with standards. There was Bamboo Working Circle and also a Grazing Working Circle.

5. F. W. **Champion's Working Plan**, 1931-32 to 1941-42.

(*a*) *Sal Conversion Working Circle.*—This Working Circle covers approximately 42 per cent. of the total area of the division and includes the better more or less pure *sal* forests suitable for conversion to uniform forest by periodic blocks, the yield* being based on reduced areas. The conversion period is 90 years and it is hoped to attain normality during this time. Dehra Dun division is fortunate in having 60 per cent. or more of the ground already covered with established advance growth. In carrying out fellings in P. B. I, we remove trees above 12″ diameter but reserve promising groups of poles even where the stems exceed 12″. P. B. II has been allotted and here no fellings are carried out in order to guard against a fall in yield in what will be P. B. I. at the next revision. The intermediate Periodic Blocks are not allotted, only light judicious thinnings are carried out by area. In the final periodic Block the overwood is being removed in those areas where the regeneration fellings of the last plan resulted in the establishment of many fine young crops. Subsidiary cultural operations are carried out in Periodic Block I after the main fellings. Thinnings will, in accordance with a recent decision, be conducted in the young sapling crops in final Periodic Block.

(*b*) *Selection and Improvement Working Circle.*—This working circle occupies 41 per cent. of the total area of the division, and comprises the poorer *sal* forests which are considered as unsuitable for conversion to uniform

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Selection is based on fixed diameter limits and an important safeguard is that only 50 per cent. of the exploitable trees are marked for fellings. The felling cycle is 15 years. Those compartments in which *sal* regeneration failed under the previous plan have now been included in this Working Circle but no fellings will be done in them during the currency of the present plan ; these areas will be carefully re-examined at the next revision and allotment made accordingly. In this Working Circle a sustained annual yield is arrived at on the basis of reduced areas.

(*c*) *Miscellaneous Working Circle.*—Five per cent. of the total area of the division has been allotted to this Working Circle which comprises the better quality low-lying miscellaneous forests. No fellings are prescribed. The objects of management are :—

(*a*) To give the present growing stock a rest.

(*b*) To introduce a satisfactory method of regenerating a miscellaneous forest.

Object (*b*) has been achieved by a successful departmental plantation the cost of which was about Rs. 40 per acre. To avoid such expenditure *taungya* has now been introduced.

(*d*) *Khair Working Circle.*—This Working Circle overlaps other Working Circles. All *khair* trees down to 8″ diameter have meen enumerated. The minimum exploitable diameter has been fixed at 12″. The estimated annual yield is 2,000 trees over 12″ diameter.

(*e*) *Professional Graziers' Working Plan.*—Twelve per cent. of the total divisional area is covered by this working circle in which the object of management is to provide facilities for the Dairy Industry after meeting the demands of local cattle owners. Lopping is allowed on a three year rotation and rules have been framed. *Taungya*, though not prescribed, has now been introduced with the object of providing the maximum amount of leaf and grass fodder per acre.

* * * * * * * *

(4) FORESTS AND TAUNGYA PLANTATIONS.

IN

SAHARANPUR DIVISION..

Sunday, November 4th. 10-30a.m. to 2-30 p.m.

The Conference left New Forest by special bus at 10-30 A.M. and driving past Mohand Range Quarter, stopped to see the satisfactory results obtained by planting teak stumps under a moderately full overwood of *sal* and miscellaneous species in an area where *sal* cannot be regenerated. The teak was thoroughly established and the valueless overwood can now be removed.

Continuing down the main road to the forest boundary, the party drove eastwards along a forest road some three miles to the Baniawala *taungyas.* The areas planted in 1933, 1934, 1932 and 1931 were inspected in turn, and made a very favourable impression on the visitors. Questions of density of sowing, selection of species, duration of cultivation and thinning out the lines of plants were discussed. The party then lunched in the plantations, Mr. Chaturvedi kindly supplying refreshments, and returned to Dehra Dun.

Note by M. D. Chaturvedi, Divisional Forest Officer.

The Saharanpur Forest division comprises the southern and as such the warmer slope of the Siwalik range, extending from the Jumna in the north-west to the Ganges in the south-east, a distance of about 50 miles. The total area of the division is about 300 sq. miles. The forest vegetation largely consists of a heterogeneous mixture of species of sub-tropical and tropical origin. As a general rule, the Siwalik sandrock and upper conglomerates met with in these parts support poor types of forest not unlike those of Central India, and comparing unfavourably with those which the Nahan sandstone of earlier origin supports in Kumaon. The flora changes with altitude and the moisture content of the soil. Owing to the inherent dry nature of these southern slopes, tree growth is stunted and stocking generally poorer than what obtains along the northern slopes. In the plains areas, natural regeneration is generally absent owing largely to lack of moisture and high grazing incidence. The last decade or two have been characterized by excessive droughts and high temperatures resulting in the continuous drying up of trees growth along the foot of the Siwaliks and in the plains. In 1929, the situation became so grave that all green fellings were suspended in the dry zone.

Taungyas.—Natural regeneration is strikingly scarce. Artificial regeneration in plantations, apart from involving prohibitive costs (Rs. 50 to 60 per acre), was not attended with any measure of success and had ultimately to be given up. In 1930 Mr. Bhola conceived the plan of regenerating these moribund areas by means of *taungyas*, and to attract cultivators he naturally selected first the plains areas adjoining the cultivation. The main obstacle, however, was lack of drinking water particularly during summer, and although various means have been devised to overcome this difficulty, a satisfactory solution of this problem is not yet in sight. When funds permit a well may be tried, but chances of reaching water level at moderate cost appear to be rather remote. Opposition from local zamindars, the existing low prices of agricultural produce, resentment of surrounding population to any limitation of their grazing facilities, droughts, and the stony nature of the soil are some of the adverse factors which had to be overcome. In the beginning, facilities of every description were provided for the cultivators. An important concession worthy of mention was that all trees standing on the area were given free to the tenants. Later on, poles of valuable species were withheld, and since last year the trees were sold before handing over the land to the cultivators. A rental of 8 annas per acre is also realized.

Objects of Management.—At first, the chief aim was to get the *taungyas* going. Later on when the *taungyas* began to get established, the object of management began to be clearly laid down. In most of the plains *taungyas* the object at present is to provide grazing, leaf-fodder, wood for agricultural implements, and a certain amount of timber. In a *sal taungya*, the object is to grow timber trees, *sal* if possible.

Progress of taungyas.—The following areas have already been brought under *taungya* :—

Range.	Forest crop sown in				
	1931.	1932.	1933.	1934.	Total.
	(Area in acres.)				
1. Mohand	46	81	79	152	358
2. Dholkhand	..	..	102	182	284
3. Hardwar	75	105	130	366(98)	676
4. Barkala	..	..	..	18	18
Total ..	121	186	311	718(98)	1,336

The total area sown in 1934 amounted to 816 acres including resowing of previous failures (98) acres.

Costs.—The costs incurred are chiefly connected with seed collection and arrangements of water supply. In the Pathri areas where water is easily available the costs are very much less. An idea of costs may be had by the following statement for the Baniawala *taungyas* :—

Plots.	Total cost to date.	Area.	Cost per acre.
	Rs.	Acres.	Rs.
1931	188	46	4
1932	232½	81	2¾
1933	186	79	2¼
		106	2
Total ..	815¼	212	3¾

To this should be added Rs. 10 per acre for the value of the trees given free to be cultivators. Thus in the past, the cost of raising *taungya* plantations at iawala has been on an average Rs. 13¾ per acre. This year trees have been before handing over the land to cultivators and cost per acre is not likely to Rs. 4 per

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Species used.—The planting technique consists of sowing forest species along lines 20 to 25 feet apart. The species tried so far are *Acacia catechu, Shorea robusta, Terminalia tomentosa, Albizzia lebbek, Delbergia sissoo, Dendrocalamus strictus, Kydia calycina, Bauhinia malabarica, Anogeissus latifolia, Stereospermum suaveolens, Bombax malabaricum, Terminalia belerica,* and *Morus alba.*

General Remarks.—The condition of tenants despite the low prices of agricultural produce is very satisfactory. As a matter of fact, it was one of the cultivators who brought the tree crop at the auctions before the land was distributed to the tenants this year. Medical facilities are provided, especially in the malarious Pathri areas. The cultivators have very much resented the recent withdrawal of the concession of free wood but are getting used to it. Before the concession was withdrawn a vast number of cultivators had applied for forest land, but now only a limited number of really hard working men care to come and settle down.

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(5) THE WORKSHOPS AND LABORATORIES OF THE ECONOMIC BRANCH.

Saturday 1st November, 2 p.m.—4 p.m.

Mr. H. Trotter, the Forest Economist, conducted the members of the conference explaining points of special interest.

In the Timber Testing Section they were shown different types of testing, including a constructional test on a large beam of Madras laurel (*Terminalia tomentosa*). They were also able to see static bending on Project I material, shear and hardness tests, and compression tests parallel to and across the grain. In the moisture determination laboratory they were able to see a torsion test and a glue shear test on plywood in addition to the popular testing of a tea box in the large drum box testing machine. Mr. Seaman, the Officer in Charge of Timber Testing was present and explained the technical details of the different tests to those present.

In the Woodworking Section, Mr. Nagle, the Officer in Charge, peeled a log of rosewood (*Dalbergia latifolia*), on the rotary veneer lathe when the visitors were present, and they were able to see the different processes of plywood manufacture, including drying veneer sheets in a steam heated plate dryer, gluing and pressing. In the Woodworkshop there was a display of different forms and uses of plywood and veneers, and also an exhibition of spray polishing with cellulose acetate (Duco) polish.

In the Minor Forest Products Section the visitors were much interested in the F. R. I. portable charcoal kiln and the briquetting of charcoal dust with suitable binders. The kiln was first shown with the top open to display the method of stacking the billets, and later it was closed and lighted, to demonstrate the simplicity of this operation.

In the Wood Preservation Section the new arsenic-copper preservative now known as Ascu was described and demonstrated by the inventor Mr. S. Kamesam, and members of the Conference were able to see for themselves the advantages and cheapness of this new preservative treatment.

In the Paper Pulp Section, Mr. Bhargava explained the method of disintegrating bamboo and the manufacture of pulp and paper from this product. At the time of the visit an art book paper was being made and the method of manufacture proved to be of considerable interest to many who had not previously seen the manufacture of pulp and paper.

In the Seasoning Section, Dr. Kapur explained the possibilities of the new smoke kiln and also the advantages and cheapness of the new "oscillating" process of seasoning wood. This process reduces the time taken in seasoning by about half that usually required under the better known kiln seasoning methods and reduces the cost by about two thirds. In addition, the timber itself appears to come out of the kilns in better condition than under the older methods of kiln drying. A demonstration with an electric moisture metre was also given and the visitors were surprised to see that the moisture content of wood could be determined in a matter of seconds as opposed to the older methods which took days.

This completed a most interesting and instructive tour which, judging by the opinions expressed, was warmly appreciated by all present.

RESOLUTIONS.

The draft resolutions which had passed through the hands of the Resolutions Committee, were read out by the Chairman at the last meeting of the Conference. Each was proposed, seconded and voted on in turn, and all were passed, mostly without further alteration, no divisions being called for.

The Secretary requested that a further resolution be passed granting him authority for dealing with the papers and reports of debates with a view to publication. Such a resolution was proposed by Mr. Howard, seconded by Mr. Shebbeare and passed by the Conference.

The remaining resolutions are appended.

RESOLUTION ON ITEM 1 (*a*)—(*c*).—(Functions of the Central Silviculturist).

RESOLVED that—

For the quicker circulation between provinces of the results of research work, this conference considers that the necessary arrangements should be made for an advance copy of the annual research report of any one province to be seen without delay by the Silviculturists of other interested provinces.

2. *Co-operative methods of investigation such as have been adopted for the problems connected with sal regeneration and management and bamboo management provide the most satisfactory way of dealing with major problems which concern several provinces. The regeneration of evergreen forest should next be taken up on similar lines and statistical problems in irregular crops might be dealt with at the same time. Forest grazing management and fir regeneration should be investigated by the provinces and States interested as soon as an opportunity arises.*

3. *When a provincial Silviculturist hears of work in another province, which he considers to be of special importance to his own, he should make it his business to visit the place and obtain first hand knowledge of what is going on. It is hoped that Provincial Governments will assist in this.*

RESOLUTION ON ITEM 1 (*d*).—(Photographic Manual).

RESOLVED that—

The time has now come for action to be taken for the compilation of a Manual of Forest Photography. Realising the differences of equipment and attainments, this Conference considers that the requirements could most usefully and economically be satisfied by the compilation and separate publication of (i) *general information and hints likely to be useful to the average forest photographer, and* (ii) *a much more detailed manual for research officers and the more serious forest photographer.*

The Conference further considers that in the first instance no one person could be asked to compile all the information required, and recommends that all the notes and draft lists of contents that have been prepared for this conference should be sent to all Provincial Silviculturists, who should circulate them to all interested Forest Officers in their Provinces inviting further suggestions. All suggestions should then be sent to the Central Silviculturist who should arrange for their final compilation.

RESOLUTION ON ITEM 2.—(Filing System).

RESOLVED that—

The report of the committee be accepted. As the subject is too complicated to settle in the time at the disposal of the conference, it is suggested that the existing scheme be continued till a better is evolved but that Dehra Dun, local silviculturists and utilisation officers should attempt by mutual agreement to evolve such a scheme, and when evolved, it should be adopted. It should be shown for information at the next conference. (For the report of the committee, see page 52).

DRAFT RESOLUTION ON ITEM 3.—(Silvicultural libraries).

RESOLVED that—

As difficulty is experienced in procuring copies of cheap foreign publications recommended by the Central Silviculturist, it is suggested that indents may be placed with the latter and that he should procure all copies on one order, the cost being borne by the actual recipients.

RESOLUTION ON ITEM 5.—(Glossary).

RESOLVED that—

This Conference accepts the alterations of the Glossary recommended by the committee, and recommends that they be included in the next edition published, the necessary correction slips being issued meanwhile.

RESOLUTION ON ITEM 6.—(Research methods).

RESOLVED that—

The recommendations of the Committee for amendments and additions to the Silvicultural Research Manual be adopted. (*cf.* p. 63).

RESOLUTION ON ITEM 6 (*a*).—(Assessment of Natural Regeneration).

RESOLVED that—

1. *This Conference accepts the method of linear enumerations by squares as the standard method of assessing natural regeneration, while still recognising the value of compact indicator plots for the study of individual plants under given conditions.*

2. *The method to be followed and the factors to be evaluated should be as detailed in the Experimental Manual, but the percentage stocking should not be reduced to a basis of 1000 plants per acre ; instead of this, it should be the actual percentage based on the number of stocked and unstocked squares.*

3. *No definite establishment height should be fixed for each species to be applicable to all India, but agreement should be reached between Provinces concerned fixing a standard establishment height for a species in the same type of forest.*

4. *The possible value of a more intensive enumeration of the regeneration at the initiation of an experiment and at periodic intervals in its progress should be kept in mind and carried out wherever feasible.*

RESOLUTIONS ON ITEM 6 (*b*), (*c*), (*d*).—(Soil and Ecological problems).

RESOLVED that—

1. *This conference desires to bring to the notice of Government that the appointment of an Ecologist has been considered so essential at the Forest Research Institute that it has been shown on the cadre of the Institute since 1920, but this post has not yet been filled.*

2. *This conference believes that work on soils and ecological problems is of the greatest importance in the elucidation of problems connected with the regeneration of forest crops. Such work is essential both in the F. R. I. and in the Provinces. The assistance of an expert in this branch of knowledge is urgently required.*

3. *This Conference also urges that Provinces should give facilities wherever possible for their officers to take up work on these subjects.*

RESOLUTION ON ITEM 6 (*g*).—(Irrigated Plantations).

RESOLVED that—

This Conference recognises the importance of problems connected with irrigated plantations, but considers that owing to the great differences of conditions, the problems can only be satisfactorily dealt with by the Provinces concerned. The Central Silviculturist should continue, as at present, to keep himself acquainted with progress in the Provinces and to give advice or suggest co-operation where it appears that different Provinces are dealing with similar problems.

RESOLUTION ON ITEM 6 (*h*).—(Record of Expenditure on Experiments).

RESOLVED that—

This Conference considers that records of expenditure on experiments should invariably be maintained for Stage II experiments, but that records of cost should only be maintained for Stage I experiments if considered feasible and useful.

Further, that no standard forms can be laid down for records of expenditure and forms must be devised according to local conditions.

RESOLUTION ON ITEM 7.—(Seed origin).

Resolved that—

This Conference is of opinion that the investigation in progress for teak will meet present requirements in this field provided it is completed according to plan. The later maintenance of the existing plots must be standardised.

Where any need for similar investigation on other species is felt, a co-operative investigation should be made on the lines which have been found satisfactory for teak.

RESOLUTION ON ITEM 8.—(Pure teak problems).

Resolved that—

The Central Silviculturist be requested to revise Bulletin No. 78 in the light of the experience acquired since it was published.

RESOLUTION ON ITEM 9.—(Regeneration of tropical evergreen forest).

Resolved that—

1. *This Conference considers that the recognition of sub-types of evergreen rain forest is required for management in South India (Madras, Mysore and Travancore), that such a sub-division is a practical proposition, and that the provinces and States concerned should collaborate in arriving at a classification that can be accepted.*

2. *Experiments in natural regeneration and artificial regeneration be made on the lines indicated in the Central Silviculturist's note, and that silviculturists in each province concerned should keep in close touch with the work being done in similar types of forest in other provinces. This conference recognises the probable economic advantages of concentrated regeneration in the most accessible places.* (*cf.* p. 137).

3. *Clear felling followed by artificial regeneration with evergreen species using cover crops and nurse crops has proved practicable at least in the early stages in Bengal and Assam. This method should also be investigated in Southern India. Such investigations should be kept on a strictly experimental scale, and should be paralleled by similar experiments in raising concentrated plantations under shelterwood.*

4. *Although past experience has provided examples of successful replacement of evergreen forest by deciduous crops, notably teak, expensive failures have also occurred. Extreme caution is, therefore, desirable in undertaking any such change on a large scale, and if for economic reasons it is desired to replace the natural evergreen forest by more valuable species, evergreen species or semi-evergreen species should be preferred. It is further considered that good general utility timbers are preferable to heavy constructional timbers or sleeper woods.*

RESOLUTION ON ITEM 10.—(Artificial regeneration with the Selection system).

Resolved that—

1. *Special steps to obtain the regeneration of valuable species in the selection forest are essential.*

2. *The investigation of methods of obtaining such regeneration should be continued ; the gap method as already prescribed in Madras Working plans affords an opportunity for such investigation.*

RESOLUTION ON ITEM 11 (*a*), (*b*), (*d*).—(Statistical Code).

Resolved that—

This Conference accepts the proposals of the Central Silviculturist for additions and corrections to the 1931 Statistical Code, and recommends that if possible a new edition of the Code be issued. For Proposals see page 178.--If this cannot be done, then only important short correction slips should be issued, and other matters should be dealt with by issuing a separate circular to those concerned. This Conference further recommends that for stump analysis work the method on a diameter basis used for irregular crops should be adopted as standard for all crops.

RESOLUTION ON ITEM 11 (*c*).—(Statistics of irregular crops).

RESOLVED that—

The report of the Committee be accepted as amended in debate.

Amended report.—Papers describing the present methods and objectives of statistical research in irregular forests most of which are mixed, were submitted by Assam, Bengal, United Provinces and Madras while a note by the Central Silviculturist summarised the results of the last (1929) conference and subsequent developments and made suggestions for the future. These papers established the following points :—

(1) That there may be different objectives and therefore different methods of statistical research in mixed irregular forests, *e.g.*,

(*a*) a semi-botanical survey (Bengal).

(*b*) Data required by Working Plan Officers in prescribing the yield of a single species in mixed forests (U. P.).

(*c*) Data required by Working Plan Officers in prescribing the yield of several species in mixed forests (Madras).

(2) That there must be a clear definition of the objective before any such research is started. Only then can the scope and methods be decided which must ensure that the objectives are attained.

(3) That statistical research is at present chiefly required in mixed forests where only a few species (out of many) are exploitable. Yield tables for such forests are impossible at present.

(4) That long linear plots 1 or 2 chains broad and several miles long in each Working Circle or forest type appear to be the best form for such research and the method of successive plot enumerations appears the only feasible method of collecting the required data either for botanical or working plan purposes. The enumerations should whenever possible be made shortly before a main felling, with check after the felling has been carried out and again shortly before the next felling. Interim measurements would serve to supply provisional data and another check should be made after the second felling if possible. The length of line must be sufficient to enable it to be safely assumed that the lines cover the full range of conditions of the area. This is especially necessary where quality classes cannot be determined. The lines should be supplemented by compact plots 1—5 acres in extent in approximately pure patches of forest which come nearest to the theoretical selection forest ; these plots to be maintained as permanent statistical plots and treated under the selection system as defined in the glossary.

(5) That every stem (over a minimum diameter) of those species for which data are required should be measured and recorded by diameter or girth classes, and not only selected stems.

(6) That where Working Plan yield calculations are to depend on statistical research, the simplest possible objectives should be adopted to start with. It is for example useless for the Working Plan branch to ask for the *normal total growing stock* of one species in a mixed forest, but it is reasonable to ask for the *distribution of diameter* classes to sustain the present selection yield.

(7) That sub-division into quality classes, crown classes, canopy classes, etc., should, where feasible, be rigidly confined to the minimum required to attain the objective, and all unnecessary elaborations excluded. In some types of forest, no such sub-division is feasible, *e.g.*, quality in moist evergreen. Over-elaboration tends to make both the research itself and the application of results to Working Plans impracticable.

(8) That where some tree classification is considered advisable, the following should be adopted :—

(*a*) Freedom of crown—(*i*) Dominant, (*ii*) Dominated, (*iii*) Suppressed

(*b*) Size of crown, (*i*) Large, (*ii*) Medium, (*iii*) Small.

(9) That it is at present too early to try to standardise methods of analysis and application of results.

The Committee, therefore, recommends that the Central Silviculturist be asked, in consultation with provincial research officers, to publish a note describing the technique so far developed in different provinces, with suggestions for methods of analysis and application of results in future. The Committee further recommends that, as the subject is of importance to most provinces, co-operative investigations should be undertaken and the Central Silviculturist and provincial research officers should keep in close touch.

RESOLUTION ON ITEM 12.—(Yield Tables).

RESOLVED that—

In view of the fact that sufficient data are available, the compilation of yield tables for teak plantations would serve a useful purpose and should be undertaken by the Central Silviculturist.

RESOLUTION ON ITEM 14.—(Thinning research).

RESOLVED that—

1. *The recommendation of the last conference be confirmed that we should continue to take every opportunity of laying out as nearly comparable sets of plots as we can find, as the most economical method of finding out what we need to know in this field. Even where initial comparability falls short of the standard aimed at, every additional set of plots provides valuable data for comparison with other sets.*

2. *More crown thinning plots are needed especially for sal and deodar.*

3. *Heck's and Gehrhardt's methods of thinning should be added to our standard list to be tried where an opportunity occurs. Both methods would be applicable to sal and deodar, whilst Heck's should be valuable for these species as well as for teak where there is no sale for small sized trees.*

4. *Diameter distribution tests should be added to the routine testing of comparative plots.*

5. *Hart's, Geerling's and Grochowski's suggestions should be tried by the Central Silviculturist in the Institute plantations or in suitable crops elsewhere.*

6. *A standard classification of thinnings in young plantation crops is required on the lines of the Classification of thinnings in more mature crops which have developed more definite crown classes.*

RESOLUTION ON ITEM 20.—(Forest grazing).

RESOLVED that—

This Conference considers the development of investigations for the improvement of forest grazing a matter of the utmost importance and therefore recommends that the experiments started in several provinces since 1929 should form the subject of an all-India investigation. In the co-ordination and development of these experiments the assistance and collaboration of the Agricultural Departments should be invited, particularly with regard to a systematic ecological study of the grasses and their nutritive value.

This Conference also considers that the reduction of the herds of inferior cattle, the encouragement of stall feeding and the control of grazing are the only final solution of the grazing problem in India.

RESOLUTION ON ITEM 21.—(Erosion).

RESOLVED that—

This Conference recognises that Governments realise the importance of this erosion question and have taken some steps on Resolution 21 of the last Silvicultural Conference to prevent the spread of erosion, e.g., the Punjab Government. The Conference would repeat that this question of erosion is of vital importance and urges that intensive propaganda should be started to educate public opinion.

RESOLUTION ON ITEM 22.—(Preservation Plots).

RESOLVED that—

This Conference considers that a satisfactory beginning has been made in preserving examples of natural forests undisturbed by human interference. Further work on more systematic lines should be continued.

RESOLUTION ON ITEM 23.—(**Mixture of species in plantations**).

Resolved that—

This Conference recognises the importance of raising mixtures in plantations and is of the opinion that it may be undesirable to raise pure plantations of species that do not grow pure in nature. Experiments should be carried out to study this.

Sporadic attempts with experiments have been made in the past, but have usually failed owing to the lack of knowledge of the silviculture of the species concerned. It is therefore suggested that the Central Silviculturist should issue a Bulletin dealing with the subject, on the lines of Bulletin No. 78 of 1932 (Problems of Teak Plantations), giving past work and experience in India, and also giving the different methods in vogue in Europe and other countries with suggestions for their application to Indian conditions.

RESOLUTION ON ITEM 24.—(Teak Plantation Technique).

Resolved that—

The Central and Provincial Silviculturists should collect available informations, publish it and draw up a general programme to systematise further research in close co-operation with the territorial staff.

RESOLUTION ON ITEM 25.—(Fire Records).

Resolved that—

The Inspector-General of Forests be asked to approach the Government of India to allow Provinces to modify Code Form 14 and record the results of fire-protection as they consider most suitable for local conditions, provided that the information required by the Inspector-General of Forests for Statement VIII of the Annual Return of Statistics relating to Forest Administration in British India is given clearly and concisely.

RESOLUTION ON ITEM 26.—(Next Conference).

Resolved that—

That the Conference should be held at least every 5 years and at shorter intervals if possible.

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CONCLUSION OF THE CONFERENCE.

The last full session took place on the morning of Saturday, November 3rd though the inspections of the workshops of the Economic Branch of the Research Institute and the excursion to the Saharanpur *taungya* plantations were made later.

After the Resolutions had been discussed and passed, the Chairman called for a vote of thanks to the Secretary, Mr. Champion, referring to the large amount of preliminary work necessary for such a conference and the importance of timely preparation to the success of such meetings ; the conference also accorded its thanks to the two Assistant Secretaries, Messrs. Allah Baksh and Laurie.

Mr. Shebbeare, on behalf of the visitors, thanked the Inspector-General for convening the Conference, which they all considered had been most successful and helpful to the general progress of Indian forestry. He also thanked the staff of the Research Institute for the special work done in connection with the conference and for their hospitality ; and the Divisional Forest Officers of Dehra Dun and Saharanpur divisions for the most interesting forest inspections they had organised and for their hospitality on those occasions.

Mr. Trevor replied and also voiced the congratulations of the Conference to Mr. Bridge, Divisional Forest Officer, South Coimbatore division, on the excellent cinema film he had allowed to be shewn dealing with teak plantation work, the first purely silvicultural film known to have been made in India. Mr. Trevor also expressed the thanks of the Conference to Messrs Shebbeare, Stewart, Mobbs, MacAlpine and Murty Rao for submitting their interesting cinema films for exhibition ; and to Messrs. Laurie and Shebbeare for running the exhibition on the evening of November 1st ; also to Messrs. Mobbs and Laurie for arranging the interesting exhibit of forest photographic work which was on view during the latter half of the session.

The Conference adjourned *sine die* shortly after noon.

ITEM 1 (*a*)—(*c*).

Organisation of Silvicultural Research.

Notes were received from Bengal, Bihar and Orissa, Bombay, Central Provinces, Kashmir, Madras, Punjab and the United Provinces. A summary of these notes was compiled and circulated by the Central Silviculturist before the conference. (For these notes see pages 30—33.)

Mr. PRATAP SINGH (Punjab) opened the debate (*cf. infra*) with a brief general survey of the position. The question of the form and circulation of annual research reports was brought up by Mr. HOMFRAY (Bengal) who pointed out the impossibility of his undertaking any further office work with his present staff. Mr. CHAMPION stated that he had submitted a paper on the subject for the consideration of the Board of Forestry in the previous week and understood that body had reached a decision as to the procedure to be adopted. Mr. HOWARD (United Provinces) spoke on the necessity for extreme brevity in reports intended to be read by the territorial staff and cited the U. P. pamphlets as an experiment in this direction. Mr. MOBBS (United Provinces) stated that no lengthy detailed report was written in his province as it was considered unnecessary. The Central Silviculturist then asked for opinions as to which of the proposed co-operative investigations should first be undertaken and representatives of all provinces replied with the result that forest grazing, statistical research in irregular crops, and regeneration of evergreens appeared most called for.

The following resolution was passed, having been proposed by Mr. PRATAB SINGH and seconded by Mr. F. C. OSMASTON.

RESOLUTION ON ITEM 1 (*a*)-(*c*).

RESOLVED that—

1. *For the quicker circulation between provinces of the results of research work this conference considers that the necessary arrangements should be made for an advance copy of the annual research report of any one province to be seen without delay by the Silviculturists of other interested provinces.*

2. *Co-operative methods of investigation such as have been adopted for the problems connected with* sal *regeneration and management and bamboo management, provide the most satisfactory way of dealing with major problems which concern several provinces. The regeneration of evergreen forest should next be taken up on similar lines and statistical problems in irregular crops might be dealt with at the same time. Forest grazing management and fir regeneration should be investigated by the provinces and States interested as soon as an opportunity arises.*

3. *When a Provincial Silviculturist hears of work in another province, which he consider to be of special importance to his own, he should make it has business to visit the place and obtain a first hand knowledge of what is going on. It is hoped that Provincial Governments will assist in this.*

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Report by the Silviculturist, Forest Research Institute, on action taken on the corresponding resolution passed by the 1929 Conference.

The 1929 Resolution on Item 1 (*a*), *Functions of the Central Silviculturist and Staff required*, was as follows :—

RESOLVED *that this Conference accepts the report of the Committee recommending the adoption, with certain modifications, of the Central Silviculturist's proposals.*

Report of the Committee (as amended by the Conference).

The Committee recommends that the relation of the Central Silviculturist to the Provinces be further defined as follows :—

I.—*Statistical.*

1. The Central Silviculturist should continue to undertake all sample plot calculations as a routine measure.

Item 1 (a)—(c).]

2. The Central Silviculturist should investigate thoroughly methods of forest statistical research, and make proposals for consideration where the need is felt for collection of data.

3. The Central Silviculturist should arrange to give assistance in the field to Provincial Silviculturists on application from them, and thereby keep his staff in touch with forest work.

4. The Central Silviculturist should undertake compilation of yield and volume tables or any other similar work in which help is required by the provinces. If a province wishes for any reason to do such work itself, the connected records at the Research Institute should be made available for the purpose. The Central Silviculturist should also propose a standardised procedure for such operations as lend themselves to it; a revised and extended Statistical Code is required for this. Resolutions would be passed on these matters at the periodical Silvicultural Conference.

II.—*Experimental.*

5. The Central Silviculturist should make a special study of methods of experimental research and circulate useful information collected. A general guide for the conduct of experimental research on silvicultural problems would be very helpful to research officers in the provinces. It should advisedly include, as a separate part, prescriptions for procedure and for the use of forms where their introduction would be definitely helpful and not a hindrance to individual initiative.

6. The Central Silviculturist should see provincial experimental plot files annually, as far as this is practicable, to enable him to maintain his records up-to-date, and should record any comments or suggestions he may desire for consideration by the Provincial Silviculturist. He should pay special attention to co-ordination of work and co-operation between provinces in problems affecting more than one province.

7. The Central Silviculturist should similarly see as many of the provincial experimental plots as possible. He should also see other investigations with the same object.

8. The Central Silviculturist should undertake such original investigation work as he can usefully attempt under Dehra Dun climatic conditions and with such assistance as he can be given. Such work should as far as possible be selected from among proposals received from the provinces.

9. Under special conditions, the Central Silviculturist might arrange with the provincial authorities to initiate if not maintain special investigations in a province where the need for them was felt by either party.

The Committee also reports with regard to the staff of the Central Silviculturist, that it considers that requirements must depend on the extent of the help asked for by province under Heads 3 and 9 and it appears that a good deal of help may be asked. It is not found possible to do more than to recommend that the Central Silviculturist's trained staff should be maintained up to the strength found necessary by him to undertake such work.

The Government of India accepted generally the recommendations made in this resolution, but considered that it was not possible at present (1931) to strengthen the staff of the Central Silviculturist owing to the financial stringency. His assistance to provincial research in the field and in the initiation or maintenance of special investigations must therefore be limited to whatever help he may find it possible to give with the existing staff. (G. O. No. 453-F., dated 22nd April 1931, to the Inspector-General of Forests.)

The Central Silviculturist has taken the action recommended under all of the four statistical and five experimental heads of the resolution. Since 1929, it has proved possible to send statistical or experimental field parties, or both, to the Punjab, United Provinces, Central Provinces, Bihar and Orissa, Bengal and Madras. Since the 1929 conference, the Central Silviculturist has toured seeing experimental and sample plots and silvicultural work generally in all major provinces except Burma (visited 1926-27), Upper Assam (1926) and Bombay (1929).

An important further development has been the organisation of co-operative investigations exemplified by those on teak seed origin, *sal* regeneration and management, and bamboo management.

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SUMMARY PAPER ON ITEM 1 (*a*)—(*c*).

By H. G. Champion, *Silviculturist, Forest Research Institute.*

(*i*) ***Quicker circulation of information.***—It is suggested that a list should be drawn up shewing which provincial silviculturists require to see the full annual research report of each province. Where the full report is printed, copies would be issued in accordance with this list directly by each province. Where the full report is not printed, the extra copies needed should be typed for circulation : as the provincial silviculturist has inadequate staff, it is suggested that the necessary copying should be done in the Chief Conservator of Forests' (Conservator of Forests') office.

The following draft list is put up for correction :—

Province.	*To receive reports of.*
N.-W. F. P. ..	(Punjab, U. P.—no Silviculturist at present.
Punjab ..	(N.-W. F. P.), U. P., Sind, C. P.
U. P. ..	U. P., Bengal, C. P. (Assam ?).
Bihar & Orissa..	N. W. F. P., Punjab, Bihar and Orissa, C. P., Bombay.
Bengal ..	U. P., Assam, Bihar and Orissa, Burma, Madras.
Assam ..	Bengal, Burma, (U. P. ?).
C. P. ..	U. P., Bombay, Bihar and Orissa, Madras.
Madras ..	Bihar and Orissa, Burma, Bombay.
Bombay ..	(Punjab, Madras, C. P.—no Silviculturist at present)
Coorg ..	(Madras, Bombay—no Silviculturist at present).
Burma ..	Assam, Bengal, Madras.

If this suggestion were adopted systematically, the Central Silviculturist would only invite the attention of provincial silviculturists to items likely to interest them in reports other than those received by them.

Madras points out that the circulation of annual and longer period programmes might be circulated with the same object.

Madras also suggests that fuller use might be made of the *Indian Forester* for publishing results without delay and to a wider circle.

The *Central Provinces* suggest that the Central Silviculturist should receive copies of all local inspection reports on silvicultural matters for circulation to other provinces likely to be interested.

Madras suggests that provincial silviculturists should send to the Central Silviculturist copies or at least references of interesting information which they are putting on their own ledger files and which they know or think probable he will not have seen. Such information might be in the provincial silviculturists' own inspection notes, unofficial experiments, local literature, etc.

(*ii*) *Co-operative investigations.*—The following have been suggested :—

1. Regeneration of evergreen forests (Bengal).
2. Classification of forest types of India (1929 Conference).
3. Regeneration methods for teak (C. P., etc.).
4. Grazing problems (C. P.).
5. Controlled burning (C. P.).

A proposed procedure (Bengal) for organising such investigations is that the Central Silviculturist should draw up a general project after consulting the provinces concerned and suggest a programme for each. This should lead to an agreed distribution of the field to be covered avoiding unnecessary overlap and ensuring comparability of results where duplication is called for.

Such a project would probably be best drawn up in the forests in a locality where the problem in question was already under investigation, and this would be essential if the Central Silviculturist was relatively new to his post. The project would have to be elastic to allow full scope to local initiative, but the

Central Silviculturist would have to be informed without delay if any deviation became advisable or necessary. In dealing with a continued investigation means would have to be devised in each case to keep the Central Silviculturist informed of developments without increasing office work.

For most subjects, a preliminary survey is required as suggested in the *Experimental Manual*, pages 8-9, and as done for the problems of the pure teak plantation and for seed origin. If published, additional information is often received from unexpected sources, and errors which are otherwise likely to be overlooked are brought to light.

(*iii*) *Research Programmes.*—In the *Experimental Manual*, page 38, it was proposed that provinces should send a copy of their 3—5 year research programme to the Central Silviculturist and this has usually been done, in fact in many instances the Central Silviculturist has been given the opportunity of making suggestions on the draft. Madras suggests that this should be adopted as a standard procedure, the Central Silviculturist to make suggestions or criticisms on proposed methods, etc., and to suggest to other provinces that certain experiments of general or local interest and application should be repeated by them so as to get early confirmation of results. The United Provinces have printed and distributed their research programme.

It would appear desirable to adopt a standard method in this matter and the following draft is put forward for consideration :—

I. *Periodic Research Programme* (3 or 5 year).

1. A copy of the draft programme should be sent to the Central Silviculturist for his suggestions before it is formally adopted.
2. If the programme is to be discussed by a forest meeting, the Central Silviculturist's suggestions should be asked for beforehand so that items recommended by him for inclusion for their inter-provincial interest may also be discussed.
3. A copy of the sanctioned programme should be sent to the Central Silviculturist for information and record, and to the silviculturists of all provinces which have intimated their desire to have one.

II. *Annual programme.*—A copy of the annual programme should be sent to the Central Silviculturist drawing attention to any deviation from the periodic programme or addition to the latter, and to any other important points.

(*iv*) *Lists of Experiments.*—Bihar and Orissa and the United Provinces suggest that Provincial Silviculturists should receive copies of the lists of experiments maintained by their neighbours. The United Provinces is the only province which has printed and circulated their list (both Silviculturist's and Divisional plots).

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Notes from Provincial Silviculturists.

(*i*) *Bengal.*—I do not think that any suggestions which will entail further office work can be countenanced. The office staff of a Provincial Silviculturist is up to date with what is happening as required under Resolution 1 (*c*) of the last Conference. Most provinces write up a full silvicultural annual report which gives full details of the work being carried out. In some provinces these are published and in others not. At one time full provincial silvicultural reports were published annually in the "*Forest Research in India*" and it was then possible for a Provincial Silviculturist to see exactly what was being done in each province and if he wanted further details he could write for them. This has been stopped. It is now proposed only to include items of general interest—more especially those concerning definite results obtained from research. This may be of interest to ordinary members of the service, but research officers require fuller details as to experiments that have just been taken up, special notes of interest as to the lay-out of plots, negative results, etc. Thus unless a province publishes its full annual report separately the remainder of the Provincial Silviculturists are in the dark as to all that is being done in any particular province.

suggest that Provincial Silviculturists should all write up full annual reports that will be of interest to other Research Officers, and a copy of this report can be sent to the Inspector-General of Forests—who will arrange to edit it for the *Forest Research in India* ; further, that those provinces who do print and publish their full report might send a complimentary copy to all other Provincial Silviculturists, and those who do not publish them should circulate a copy to all Provincial Silviculturists for their information.

There must be several important problems of Silvicultural Research that affect two or more provinces—such as Regeneration of evergreen forests, Natural regeneration of *sal*, etc. I suggest that when a problem affects several provinces it should be taken up as an all-India one, and that all Provinces interested should combine under the direction of the Central Silviculturist in tackling it. The Central Silviculturist would draw up a scheme for experiments in consultation with Provinces concerned and allot to the different Provincial Silviculturists certain definite experiments. In this way a considerable overlap in research will be saved with corresponding saving in time and money. I feel at present that we are wasting a great deal of time in duplication of experiments in the different provinces and this could be avoided and a final answer obtained in a much shorter time if there was one directing head for such major problems. At present there is an all-India experiment unto the ' Origin of Teak Seed ' in which most of the provinces are co-operating under the direction of the Central Silviculturist, and which I understand is working satisfactorily, and I do not see why other problems should not be taken up in the same way.—*C. K. Homfray.*

(*ii*) *Bihar and Orissa.*—The present arrangement to maintain relations between Central and Provincial Silviculturists seem satisfactory, but a closer relationship between provinces seems desirable. Neighbouring provinces are likely to have problems common to one another and a greater exchange of views and experiences would be valuable. It would be useful if provinces supplied their neighbours not only with their programmes but also with a list of experiments in progress. When this has been done provincial silviculturists could decide which of their neighbours' experiments are interesting and useful and then ask for periodic summaries of selected experiments to be sent to them.

More than this does not seem possible or necessary But if this action is taken correspondence between provincial silviculturists would naturally be stimulated and a freer exchange of views result.—*F. C. Osmaston.*

(*iii*) *Bombay.*—As Bombay has no silviculturist, there is little opportunity for co-operative action, but so far as possible, Bombay agrees to take up in its research programme any subject on which the meeting may consider that it is particularly desirable to obtain results from this Presidency for comparison with similar research carried out elsewhere.

Bombay also agrees that in initiating any new subjects of research, the appropriate procedure laid down in Champion's *Research Manual* will be adopted, and the Central Silviculturist consulted as necessary, so that results may be easily comparable with those obtained elsewhere.

In view of the fact that Bombay has no Silviculturist of its own, any action which the Central Silviculturist can take under Resolution I a, II 9 of the 1929 Conference will be welcomed. (See page 28.)—*E. A. Garland.*

(*iv*) *Central Provinces* :—*Circulation of information.*—To ensure the quicker circulation of useful information between provinces, I would suggest that Provincial Silviculturists be asked to submit to the Central Silviculturist in triplicate as early as possible after they are written, copies of any notes on plantation work or other silvicultural operations written by officers in the province. The Central Silviculturist could then circulate or supply copies of the notes to other provinces likely to be interested.

Co-operative investigations.—The co-operative investigations into teak seed origin and into the treatment of bamboos are of great interest and likely to give very useful results. I would suggest similar investigations by interested provinces into grazing problems, on the lines of the investigation started in the Central Provinces, and also into the question of burning to improve reproduction conditions, to stimulate growth, or as an early protective measure, in young teak and *sal* forests.—*H. C. Watts.*

(*v*) *Kashmir.*—A start was made for the first time in Kashmir for statistical and experimental research, when a Forest Officer was deputed to Dehra Dun in 1929 to work with the Central Silviculturist and learn standard methods of laying sample plots and collecting of statistical data. In 1929, the Central Silviculturist also favoured Kashmir State with a visit and laid out three standard sample plots for the guidance of the Research Officer.

Statistical and field data for sample plots are being collected by the Research Officer on standard forms on the lines laid down by the Central Silviculturist. The sample plot files are being sent to the Central Silviculturist for calculation purposes. The number of sample plots laid down so far amounts to ninety six only. Systematic experimental research has not yet been taken up, but it is keenly felt that this side of the research work should be taken up in Kashmir on the lines laid down by the Central Silviculturist as early as possible.—*Harnam Singh Pathania.*

(*vi*) *Madras.*—News of work being done in one province takes a long time to percolate through to the Silviculturist of another province. Thus, the Madras Silviculturist was unaware of the evergreen regeneration work under cover crops in Bengal until the Central Silviculturist told him about it in February 1934 when touring in Madras.

The following suggestions are made in this connection :—

1. Annual and triennial programmes of work should be circulated (through the Central Silviculturist) to all Provincial Silviculturists. This would enable Silviculturists to repeat experiments that were being done in other provinces so as to get confirmation of results under local conditions.

2. The Central Silviculturist on receiving programmes or work should make suggestions or criticisms on proposed methods, etc., and also suggest to other provinces that certain experiments of general or local interest and application should be repeated by them, so as to get early confirmation of results.

3. Fuller details of experiments with statistical data should be given in the printed annual reports, copies of which should be sent to all silviculturists.

4. Fuller use to be made of the "*Indian Forester*" for publishing results as soon as they are obtained, as this gets round quicker than annual printed reports and is also more widely read than any other medium of communication of forest information.

No special suggestions are made for co-operative investigation,—but we are of course always willing to undertake them if applicable to this Presidency.—*M. V. Laurie.*

(*vii*) *United Provinces.*—According to present practice, the Central Silviculturist receives copies of all experimental files of Provincial Silviculturists, who are responsible for sending copies of entries, or the files themselves, from time to time. He is therefore kept fully acquainted with the progress of experimental work in all provinces, and is able to give useful criticisms and suggestions regarding the procedure adopted and possible further investigations.

This system, however, does not normally result in co-operation between the provinces, and in actual fact the Silviculturist of one province very often does not know what is being done in adjacent provinces, or, which is more important, how the experiments in other provinces are being conducted. Results published in Silvicultural Research Reports very often do not indicate the procedure of the experiments—methods of layout, record of observations and their analysis, etc. Apart from a few joint experiments, such as the All-India Teak Seed Origin experiment, the most useful form that co-operation between the provinces could take would probably be an interchange of ideas as regards procedure. In the United Provinces, for instance, it would be very useful for us to know how other provinces are tackling problems of natural regeneration, what methods are being employed for the assessment of improvement in grazing areas, how ecological changes in forest and grass areas are being studied, and so on.

To facilitate interchange of information and experience, the following suggestions are put forward for consideration :—

(1) The Central Silviculturist should take the initiative in sending files of experiments in other provinces to any Silviculturist, when he thinks that the procedure or other details of the file would be of interest.

(2) Each Provincial Silviculturist should at once send to all other Silviculturists a complete list of his experiments. The list should be kept up to date by an annual list of corrections—additions and deletions. Not less than once in 5 years, and in any case whenever a new list is made, or it is printed, a complete revised list of experiments should be sent to all Silviculturists.

(3) If any Provincial Silviculturist wishes to see the file of any experiment in another province, he should first apply to the Central Silviculturist for his copy of the file. If the Central Silviculturist's copy does not contain sufficient details of observations recorded, then the original file in the possession of the Silviculturist concerned should be asked for. Original files should be lent whenever possible, but it should be understood that the loan is for a strictly limited period only.

(4) It would of course be an invariable rule that no Provincial Silviculturist should publish any details of experiments or results in another province, without the sanction in writing of the Silviculturist concerned.—*E. C. Mobbs.*

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Report of Debate.

Mr. Pratap Singh in opening the debate said :—

The question of research organisation has been discussed at all the forest conferences held here. In 1922, it was decided to decentralise almost all the experimental work, and the Central Silviculturist was expected to act as a liaison officer between different provinces to keep local silviculturists in touch with what others were doing. At the 1929 conference, the relations between the Central and Provincial Silviculturists were further defined, but most of us are still not sufficiently aware of what is happening in other provinces. This leads to unnecessary duplication of work not always entirely comparable. Where repetition is desirable, the experiments should be so carried out that comparable results are obtained. Obviously the best course would be to draw up research programmes in consultation with the Central Silviculturist.

Again there are problems common to more than one province or State in India, which would be easier for us to investigate in co-operation with one another. It was therefore rightly stressed by the Inspector-General of Forests in his opening address that co-operation between the Silviculturists was essential for success. He also cited certain problems which could thus be tackled, such as regeneration of *sal*, regeneration of tropical evergreen forests, mixtures in plantations, etc. The Central Provinces has suggested regeneration methods of teak, controlled burning and grazing problems, to which the Punjab would like to add regeneration of fir and the study of irregular crops. Here again the services of the Central Silviculturist would be needed for drawing up a programme and distributing field work.

This decentralisation of research work also requires quicker circulation of available information. Several suggestions have been made in this connection. One is that copies of annual research reports be supplied to other provinces which would like to see them. A draft list has been prepared showing to which provinces each province might send its report. This draft would no doubt meet requirements, but can be amended as required by representatives of various provinces and States. Punjab has found this method useful and has also benefitted by exchange of actual files.

Circulation of annual and longer period programmes has been suggested with the same object, and I do not see why it should not also be done. Reports deal with past work and programmes with the future.

Other suggestions included publishing results in the *Indian Forester* without delay, and circulation to other provinces of interesting information and inspection reports received by the Central Silviculturist.

All these proposals, which have been admirably summarised by the Central Silviculturist in his note, are hardly of a controversial nature, and I recommend their inclusion in our resolution.

Mr. C. K. Homfray : In some provinces there will be a fairly large number of copies of the full research report required and if each officer is going to have a separate copy, I submit that our office staff will be unable to cope with the work of copying. Where the report is printed and published, we could naturally get copies from the publishers, but where provinces do not print their reports one copy should be circulated instead, because out of 20 or 30 pages it is quite likely that each province will only want two or three paragraphs and it will save a lot of time and trouble if one copy could be circulated in each province. I have spoken to Mr. Champion and I think he sees no objection.

With regard to the preparation of a summary, it takes a long time to prepare the full annual report which it is essential for the Silviculturist to do, and the summary is a very difficult thing for a man to do on his own annual report. It is usually done very badly indeed in my province and I know other people have difficulty in compiling these summaries. It is suggested here that Conservators should undertake the work but I do not think this is feasible in Bengal.

Mr. Shebbeare : That was discussed by the Board of Forestry.

Mr. Champion : The question of the extra typing and office work involved in producing an extra copy of the provincial annual research report for distribution to all provincial silviculturists can obviously be met in two ways. One is the way that Mr. Homfray suggested of avoiding it by reserving one copy for circulation through a considerable number of provinces ; this is liable to be a very slow method, particularly as these things will usually reach officers when they are on tour and very busy with other work and I do not think in practice provincial silviculturists will find this method very satisfactory. We might decide that this is the best procedure under the circumstances, but the other obvious alternative would be much more satisfactory if we could put it through, and that would be to arrange for the necessary extra clerical assistance. It seems to me absolutely absurd that an officer's time should be wasted over this sort of thing. I am perfectly well aware that provincial silviculturists are almost everywhere understaffed and most of them have to do an unnecessary amount of quill driving. I think if the matter were pressed, it is probable that the Research Institute could undertake the job in the general interest. We very often require a second copy of these things for ledger filing and we could strike another copy for distribution. I could not undertake this at the moment but I think it could probably be arranged in time. Possibly the provincial silviculturists and I could settle it in discussion.

The second point Mr. Homfray raised, the question of the summary, has as Mr. Shebbeare has told us already been discussed by the Board of Forestry. I was present at the discussion and it seemed to be generally agreed that the summary should be written by the Working Plans and Research Conservator as it is so much easier for him than for the silviculturist, to survey the progress as a whole. This means of course that in the majority of the provinces where there is no Conservator for Working Plans and Research, the territorial Conservator should undertake it, and he will almost certainly in practice require the silviculturist to produce the summary. I suggest that one such summary would do instead of the two usually written at present. As a matter of fact, I consider this annual survey important enough to take precedence over some of our other work. One of the defects of a good deal of our research work now and a matter we ought to take up, is the lack of a periodic summary of the progress made in individual investigations. My office is full at the moment of experimental plot files which have not been summarised for years and years. It is mainly because we are attempting to do more than we have time for, and I think the proper solution is to cut down a good deal of the work and do only such portions of the programme as we can do thoroughly. If you summarise your experiments periodically, it is not very difficult to summarise the progress made as a whole. I think this annual summary has got to be written, and I think it should be written if only for propaganda purposes to keep people in our own department and our own province informed as to the progress made. As the Board of Forestry has dealt with this already we shall presumably get orders on the subject but I take it that any further recommendation made here would receive due consideration.

Mr. Howard (Chairman) : This question of how to keep provincial silviculturists in touch with one another has come up time and time again. And every solution so far that we have offered, although it has taken up a step further for the moment, has not really in the long run taken us very far. So far as I am personally concerned I have never found that these written reports really give me any idea of what is actually going on. We found exactly the same difficulty in my province in getting the information round among our own divisional officers and others, and after a certain amount of talk we have lately introduced the publication of what we call *Leaflets*. We have also our *Bulletins* which are on our ordinary distribution list and go round to everybody. When we consider that an experiment has advanced to such a stage that we are prepared to let people know what we have done, we publish a bulletin, but on the other hand, very often while the investigation is going on we have had quite a lot of information which we could give out but which we are not prepared to stand by, and it is this we publish in our leaflets. These leaflets are only sent to our own staff to let them know what is going on, and are merely interim reports. I do not know whether the idea can be extended in any way or if it can be adopted in other provinces.

The essential point is that if from the information you send round, a silviculturist finds that there is something going on in some other province that is important to him, the only solution is for him to go to his Conservator and get permission to go to that province. If he does that, a single week will tell him more of what is actually going on than any amount of writing can do. I was lucky enough to spend a fortnight in Bengal once and that has meant that since then whenever I have seen anything in their reports, I have known what they are talking about and what they are doing. Until I went there and to other provinces I never felt the same familiarity. I would like somebody to add to the resolution a recommendation that when a provincial silviculturist finds something in any report which has a direct connection with the work that he is doing, the Government should allow him to pay a short visit to that province and actually see with his own eyes what is going on.

Mr. Mobbs : May I ask whether it is intended that the long report of 60 or 70 pages which Mr. Champion mentions should be compulsory ? Actually in the United Provinces we do not prepare a long report. We are now producing the leaflets just mentioned which keep our officers in the province in touch with interesting interim results of experiments, and the annual report we produce is actually what everybody has been talking about as a summary. I personally think from our point of view that a summary which runs to 20 pages is quite sufficient and I do not see why we should write 60 pages just for the sake of writing. We also make a summary of 3 or 4 pages for the annual administration report and it seems to me that these two sufficiently cover the whole subject.

Mr. Champion : The procedure in different provinces varies very greatly in this respect and it is for that very reason that we have so much trouble in compiling Part II of the *Annual Research Report* for all India. Actually the U. P. has led the way in this matter. The object of all these reports is to get the information read and appreciated, and the number of people who will wade through an 80 page report is very small—it consists only of those who have to. I had forgotten that the U. P. Silviculturist does not write a full report. I imagined that the report that comes in from the Working Plans Conservator was a summary of a longer report—which does happen to be the case in practically every other province. The justification for these long reports has been that divisional forest officers like to have the details of progress made in experimental work in their divisions. That is the general feeling and it is perfectly true that it is very important and always among the Silviculturist's first duties to keep them interested and informed. I am not sure myself that the divisional forest officer will look through a report unless his attention is drawn to the particular pages concerning his division. I think that is a matter which will have to be decided in each province. If the U. P. is satisfied that the D. F. O. will not read a long report, a summary report is much the best thing.

If on the contrary there is a feeling in a province (and the provincial silviculturist should know) that the details are interesting and would be read, then I think a useful purpose would be served by circulating the full report; but obviously no full report should be written expressly for that purpose.

Mr. Mobbs : May I make one point in explanation ? In the U. P., every D. F. O. has a copy of the experimental files for his division and knows as much about what is going on in them as the Silviculturist does.

Mr. Champion : That is of course exactly as it should be. I said just now the U. P. led in this matter. They circulate a printed programme and the list of experiments controlled by the Silviculturist himself, with enough information to tell what each is about; and also a supplementary list of experiments controlled by the Divisional Forest Officers. The organisation and execution of the work has advanced further in the U. P. than elsewhere, with very satisfactory results.

Mr. Howard : Speaking as a Divisional Forest Officer myself, I can assure you that when I receive a report of even 20 pages, all I do is to write on it ' file ' and that is the end of it. One of the ideas of the leaflets is that they do not give the whole mass of the stuff *at one time.* You get a small leaflet and read through it, then after a while you get another. And further, to make sure that they do learn something about the matter we endeavour as far as possible to summarise even that leaflet, and we put the summary on the first page so that the really lazy officer can look at the summary and throw it into the waste paper basket and still know roughly what we are driving at. I suggest that if every province did that it would be a good thing.

Mr. Champion : Before we actually get to the question of discussing the draft resolution, I would like to refer you to a summary note by me which all the provincial silviculturists—and I think as many other officers as I had copies for—have received. Mr. Pratap Singh gave us a very short survey of it, but there are one or two points on which further suggestions were expected in the course of the discussion, and those suggestions not having been made, I would like to draw attention to them so as to prevent their being overlooked. On the second page there is a remark headed ' *Co-operative investigations* '. Most of you know about the co-operative investigation on *sal* management and regeneration problems which resulted in a lengthy report, and several others have been suggested. I should like to ask that a clear opinion by the conference be incorporated in the resolution as to whether the *sal* investigation in particular was a step in the right direction, whether we should continue to develop that idea, or whether it is uncalled for, the same work possibly being done at less expense and equally well simply by correspondence and compilation here. Actually we all derived a great deal of practical benefit from the *sal* tour in that it resulted in officers of one province who are keen on this side of the work visiting other provinces and getting some idea of the local forests and forestry. Six provinces participated in that investigation and at least six provinces or States are concerned with the teak technique or certain other forest problems.

The subjects now proposed must be put in order of importance because each one of them is a year's work.

Mr. Osmaston : With regard to these co-operative investigations, we simply have not got the staff to lay out more experimental plots. How much would the Forest Research Institute be able to contribute in the way they did for the bamboo plots ?

Mr. Howard (Chairman) : The fact that you pass a resolution saying that you want co-operative investigations made does not bind you to lay out any single plot you may be asked for. Though we are perfectly prepared to agree to this resolution, I can assure you that if they asked us to lay out a lot of new plots in the United Provinces, we should have to refuse because we have so much in hand that our silviculturist is already very much in arrears.

Mr. Champion : I did not mention the bamboo investigation that we have made. The bamboo work that we did in the provinces was definitely laying out experimental plots as it was desirable that they should be on similar lines in different provinces and provinces had no staff to do the work. It was a very different thing from our *sal* investigation where the main object was to get interested officers together for discussion both in the forests and at the table and to summarise the position and see what further work was required. The suggestions made were the outcome of the tour, but we left it to the provinces to adopt those suggestions which are nothing more than recommendations.

[Representatives of provinces then recorded their opinions as to the relative importance of the several suggestions for co-operative investigations with the following results, 1, 2 and 3 representing the order for the province in question :—

Statistical Research in Irregular Crops.—Bombay 1, Burma 1, Kashmir 1, United Provinces 1, Punjab 2, Central Provinces 2, Assam 2, Bihar and Orissa 3.

Grazing problems.—Central Provinces 1, Punjab 1, Bombay 2, United Provinces 2, Madras 2, Kashmir 2.

Regeneration of evergreen forests.—Bengal 1, Madras 1, Travancore 1, Assam 1, Mysore 3.

Regeneration methods for teak.—Bihar and Orissa 1, Mysore 1, Central Provinces 3.

Fir and Deodar regeneration.—N.-W. F. P. 1, Punjab 3, Kashmir 3.

Controlled Burning.—Bihar and Orissa 2, Mysore 2.]

Mr. Howard : Is it agreed that we should go on with the idea of co operative research on the lines of the tour ?—(This was agreed, *nem. con.*)

Mr. Champion : It is obvious that provinces fall into two or even more groups without a great deal of overlap. Those who are particularly interested in the regeneration of evergreen forests are mostly absent from the list of provinces in which grazing problems are of first importance. In reaching a decision on the point we shall have to consider what is practicable. These subjects cannot all be dealt with in the same way, for instance in the case of statistical investigation of irregular crops, there would be nothing whatever to be gained by touring as we did for *sal*. We are here concerned mainly with methods of investigations, the actual work to be done by the provincial silviculturists on lines agreed as most promising of clear results and standardised in order to keep the work in uniform lines.

Grazing is likewise a subject in which the Forest Department could not do a great deal because everything which should be done involves expenditure which we cannot afford to incur. The results of the C. P. experiments we shall hear later, and here again I think we can only progress by trying out different methods, as the C. P. is doing. A preliminary survey is already in progress and I think it should not be long before we can suggest lines of work to provinces which are sufficiently interested to take it up. But the question will come up, " Has the Silviculturist time to take it up and if not, can the D. F. O. do it ". I am quite certain we shall find that the majority of provinces will say that they cannot undertake it.

The regeneration of evergreens offers more promise for work of this kind. I have, fortunately for myself, been able to see most of the important centres of work and we certainly are getting somewhere with it.

The regeneration methods for teak, surprisingly enough, have drawn practically no votes. Bihar and Orissa and Mysore put it first, and the Central Provinces put it third ; the other important provinces do not include it. It would not look as though there was any particular demand for any special work on that subject. I think perhaps the reason for that is that teak work in those provinces is already such a matter of routine that everybody feels that such progress as is possible can be made by the D. F. O. who is in a very strong position as compared with the Silviculturist, for he can money and staff for it, and has to make frequent inspections as a routine measure.

So actually it looks as though we should take up the regeneration of tropical evergreen forest first and do what we can simultaneously with the irregular crop and grazing problems. It looks as though we can make some progress with these two by getting together and discussing things on the spot, and at the same time, as the Chairman has said, we can utilise the opportunity for discussing other problems of mutual interest. The North-West portion of India is rather left out of this and I see no reason why the North-West provinces and States should not co-operate in a similar way in their own special problems, such as treatment of fir forests. These problems have to be solved before the urgency arises, otherwise we get the only too common position when something must be done and prescriptions are put forward for doing things on a big scale which ought never be done until preliminary investigations have been made.

Mr. Homfray : I see that the record of the *sal* investigation suggests how far the different provinces can go in solving their own problems and I have been wondering if we could not go a step further and suggest that the Central Silviculturist might draw up a general project in consultation with the provinces concerned and suggest a programme to each.

Mr. Champion : For the regeneration of evergreen forests, which we put first in our list, I have already summarised the position. As regards the distribution of work which Mr. Homfray suggests, the more we go into these problems the more complex we find them to be. We actually found for *sal* that we had to differentiate 13 types of forests, in any one of which it would be dangerous to apply without check the results obtained in the other 12. If that applies to a relatively simple problem like more or less pure *sal* forests, it would apply still more to the complex one of evergreen forests. I think myself we could very usefully visit together the four or five centres where evergreen forest problems are met, just as we did for *sal*, discuss the thing on the spot and draw up a programme. It may be questioned whether a further summary is necessary for the regeneration of evergreens. With regard to grazing I have been trying to issue a summary for the last 2 or 3 years. The trouble is that there is very little to summarise. The information we have comes either from Europe (mainly the Alpine regions) or North America, *i.e.*, from temperate climates—in other words, nothing applying to tropical India. In India itself we have lots of petty experiments from which we cannot draw any final conclusions. We have the one systematic investigation in the C. P. which has not been going on long enough to give results, and one in Bombay, and in connection with these I think a summary would be definitely useful.

ITEM 1 (*d*).

Forest Photography.

Papers were contributed by Messrs. E. W. Carroll (Burma, p. 41), M. V. Laurie (Madras, p. 44), E. C. Mobbs (United Provinces, p. 45), H. L. Wright (N.-W. F. Province, p. 47), and E. O. Shebbeare (Bengal, p. 48), making suggestions concerning the preparation of the 'Photographic Manual for Forest Officers' which was recommended at the 1929 Conference.

Some of these papers were circulated before the conference and short notes were received from Mr. F. W. Champion, the Silviculturists of Bengal and the Central Provinces, and the Forest Research Officer, Bihar and Orissa.

A brief debate (p. 49) was opened by Mr. SHEBBEARE (Bengal), Messrs. MOBBS and LAURIE also speaking, the chief point discussed being what to include in the Manual. Mr. Shebbeare proposed a draft resolution which was accepted with minor alterations.

The following resolution was proposed by Mr. SHEBBEARE (Bengal) and seconded by Mr. LAURIE (Madras) and passed by the Conference :—

RESOLUTION ON ITEM 1 (*d*).

RESOLVED that—

The time has now come for action to be taken for the compilation of a Manual of Forest Photography. Realising the differences of equipment and attainments, this Conference considers that the requirements could most usefully and economically be satisfied by the compilation and separate publication of

- (*i*) *general information and hints likely to be useful to the average forest photographer, and*
- (*ii*) *a much more detailed manual for research officers and the more serious forest photographer.*

The conference further considers that in the first instance no one person could be asked to compile all the information required, and recommends that all the notes and draft lists of contents that have been prepared for this conference should be sent to all Provincial Silviculturists, who should circulate them to all interested Forest Officers in their Provinces inviting further suggestions. All suggestions should then be sent to the Central Silviculturist who should arrange for their final compilation.

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Report by the Silviculturist, Forest Research Institute, on action taken on the Resolution passed by the 1929 Conference.

The Resolution passed in 1929 reads as follows :—

RESOLVED *that this Conference accepts the proposals of the Central Silviculturist as modified by the Committee and in open debate.*

Proposals as accepted :

1. Every Silvicultural Research Office should have a good camera suitable for forest work.

2. Every Silvicultural Research Office should have a classified collection of photographs. The classification should as far as possible be uniform.

3. Every Silviculturist should himself photograph unless one of his staff can do it, and should look upon the camera as an indispensable recording instrument for experimental plots and the forest generally.

4. Each Provincial Silviculturist should send in annually to the Central Silviculturist a direct print of each photo likely to be of general interest, which has been added to his collection during the year. The amalgamated collection of photos from all Provinces should be circulated to Provincial Silviculturists with a note for each as to where the negative is stored. The Provincial Silviculturists would write direct to the officer holding

the negative for any prints required by them. The Central Silviculturist will similarly ask for any prints required by him, and these would be supplied on his standard size (Full plate).

5. The Research Institute should store negatives for those Provinces which wish to place them in his charge. Such negatives would be returned by the Research Institute if at any time the Province should wish to store its own collection.

6. The Photo Section at the Forest Research Institute should afford all possible assistance with photographic work in this connection.

7. The Central Silviculturist should maintain as complete a collection as possible of foreign photos and slides of general silvicultural interest.

8. As opportunity offers, trials should be made under forest conditions of possible improvements such as stereoscopic views, special appliances, etc., results obtained being circulated for information.

9. A short manual dealing with photography in the forest under Indian conditions is required. It could best be compiled by the collaboration of officers having special knowledge and experience of the subject.

The Government of India accepted this resolution as it was passed.

1. Cameras in use are reported to be :—

Assam.—Kodak Automatic, 4″ × 5″.

Bengal.—½ plate Tropical Sanderson (1930), Triple extension, Thornton shutter. Goerz Anastigmat F.|6.8.

Bihar and Orissa.—½ plate Ensign Empire camera (1929), Ross Homocentric F.|6.3. Triple extension.

Burma.—Sinclair Una ¼ plate Ross Xpress F.|4.5 Stereo fittings.

Central Provinces.—½ plate Sanderson. Cooke Anastigmat.

Madras.—½ plate Thornton Pickard Special Ruby Reflex, Cooke Anastigmat F.|4.5.

Silviculturist uses his own Agfa-Isolar 9 × 12 cms., Agfa Solinear F.|4.5.

Punjab.—3 cameras, *viz.*, Kodak No. 2-A ; ½ plate Sanderson Tropical, Ross Homocentric F.|6.3 ; no details given of the third.

United Provinces.—A full plate camera with ½ plate lens and indifferent shutter. Silviculturist uses private ½ plate camera extensively.

2. The Punjab, the United Provinces, Bihar and Orissa, Bengal, Madras and Burma have classified collections of photographs, and are believed to be using the Forest Research Institute classification.

3. Madras and the United Provinces have experienced photographers as Silviculturist. In Burma and the Punjab many forest photos by other officers have been added to the collections. Relatively few photos have been taken in the remaining provinces and to this extent the resolution has not yet been carried out.

4. A collection has been circulated annually as proposed.

5. Negatives are now stored at the Forest Research Institute.

6. A large amount of work has been done at the Forest Research Institute for the United Provinces, the Punjab and Madras, and copies of photographs taken by the Central Silviculturist in the same provinces and in Bengal, the Central Provinces, and Bihar and Orissa, have been sent out for the provincial collections.

7. Very few foreign photos have been received at the Forest Research Institute. The lantern slide collection has been increased from 497 in 1929 to 1,263 in 1934 and slides have been issued on loan to the Punjab, Bihar and Orissa, and Bengal.

8. A number of stereo photos have been taken.

9. A photographic manual has not yet been compiled as no one has been found ready to undertake the task.

[Item 1 (d).

PAPER (I).

Contributed by E. W. Carroll, *Offg. Conservator of Forests, Northern Circle, Burma.*

A Few Notes on Practical Jungle Photography.

1. Photographs taken by silviculturally-minded Forest Officers can be classified under the following heads :—

1. Close-ups of branches, leaves, flowers, fruit, etc.
2. Half-lengths, boles of trees, etc.
3. Undergrowth.
4. Medium-distance photos, *e.g.*, of regeneration.
5. Whole trees—*e.g.*, single specimens, plantations.
6. Landscapes—*e.g.*, afforestation.

2. *Apparatus.*—It is unfortunately true that the only type of camera capable of taking *all* the above subjects perfectly is a plate camera of the hand-and-stand type with a really good rising front. The camera must be a plate model as for accurate focussing (*e.g.*, for subjects 1 and 2) the ground-glass screen must be used while an exceptional rising front (all the better if combined with a swinging back) is essential for the numerous exposures one has to make of subject 5.

The great objection to these cameras is the length of time demanded by the taking of a photograph. What with assembling the stand, selecting the point of view, arranging the stand on uneven ground so that the camera is level, focussing through the back screen and testing the exposure, I have seen an eminent Silviculturist who was also an experienced photographer take a timed 25 minutes over one exposure.

This is not good enough. It is liable to prevent the taking of photographs that ought to be taken, or if the photographer is conscientious enough to insist on making exposures, it prevents him covering as much ground as he would otherwise have done in the course of a morning.

For this reason it is very well worth the while of any officer who is expected to take photographs to carry about a camera of the reflex as well as one of the hand-and-stand type. In this connection it is to be pointed out that whereas the eminent Silviculturist mentioned above took 25 minutes over a couple of exposures from the same spot, the writer, using a reflex, made four different exposures of the same subject from different points of view in rather under 5 minutes. There was nothing to choose between the two sets of photographs.

Further notes about cameras.

3. *The hand-and-stand camera.*—Whole-plate and half-plate cameras are as extinct as the dodo and should be relegated to the shelves of a museum.

With the fine grained and perfectly sharp negatives obtainable with the greatest of ease these days and the foolproofness of enlarging apparatus all that is wanted for silvicultural purposes can be achieved by a ¼ plate camera. Actually a smaller camera would do but the writer recommends ¼ plate as focussing, generally in poor light, under a dark cloth is, in practice, rather difficult with smaller sizes, and as ¼ plates are probably the commonest size of plate used and fresh supplies can always be got.

The Reflex camera.—Any good class 3¼" × 2½" or ¼ plate model would do, the main point being that it should possess as big a range for the rising front as is possible for this type of camera. The more efficient the rising front is the less often will it be necessary to make use of the hand-and-stand camera.

The ideal pair { (*i*) A Sinclair 'Una' ¼ plate hand-and-stand camera.
(*ii*) A Newman-Sinclair ¼ plate Reflex.

The writer of this note was fortunate enough to possess this combination for some years before the imposition of the 'cut'. The advantages of that particular reflex were that it took the same plate-holders as the 'Una' and that it possessed a guaranteed accurate shutter of the Compur type and not that abomination, a roller-blind. These cameras have not been made for the last ten years or more, but there are still a few on the market.

Before leaving the subject of cameras it should be pointed out that perfectly good photographs of subjects 3, 4 and 6 can be made with any camera of the Kodak type.

Miscellaneous Notes.

4. *Plates or Films.*—As far as results are concerned it is absolutely immaterial which are used.

An objection to plates is that if halation is to be avoided they should be backed and backed plates are not always easy to get. On the other hand, if a developing tank is used, plates are vastly easier to develop, fix, wash and dry than films are, and developing can be done, in fact is best done, by daylight.

Films are easier to carry about and store and any common film is more or less halation-proof.

In any case, whether plates or films are used, photographers are advised to use orthochromatic (or, after experiment, panchromatic) types and to stick to one make, so that its peculiarities become known.

While on the subject of plates there is one point that should be mentioned and that is that anyone using plates should understand the internal construction of plate-holders and be prepared to replace the strips of velvet used to exclude light. If these become worn and smooth entirely or partially fogged negatives will result.

5. *Putting plates into dark slides.*—If panchromatic plates are used there must be absolute darkness both for putting them from the original box into the slides or from the slides into the developing-tank. The writer uses one of the several changing-bags on the market and insures still further against fogging by putting a thick blanket on top of that.

With ordinary and most orthochromatic plates such elaborate precautions are not necessary. If the changes are done by day-light the changing-bag should be used. If at night it is only *direct* lamp-light that must be guarded against. The writer has found no harm to be done if plates are put in one room of a bungalow with an oil lamp burning in the next room and the door left open. Full moonlight also does no harm to a plate.

6. *Use of Changing-bags.*—When changing-bags are used on the occasions mentioned in the last para. the operations must, of course, be performed by sense of touch only.

It is by no means easy to put 12 plates either from the original box into plate-holders or from them into the tank correctly and without damage to the plates. This is particularly so on a warm day when the touch of a damp finger on the film side of the plate leaves an ineradicable mark. A very considerable amount of practice with old negatives and the thinking out of definite systems are essential before either operation is undertaken seriously.

7. *Lens-hood.*—The taking of photographs more or less straight into the sun is sometimes unavoidable and occasionally advantageous. On such occasions a lens-hood is essential.

8. *Stand.*—A first class wooden stand is essential. Time will be saved when getting the camera level if the screw is detachable. If two cameras are used the threads may not be the same and different screws may have to be carried. Spare screws should be available in case of loss.

9. *Exposure-meter.*—Modern plates and films possess enormous latitude and a possible picture can be produced with an exposure 100 per cent. or more wrong.

All the same the picture is undoubtedly better and enlargement is vastly facilitated if exposure is approximately correct.

For most open-air subjects exposure can be calculated in a few seconds from the revolving meter in the Burroughs & Wellcome photographic diary.

In shady jungle, however, the use of a more complicated meter is necessary. There are numerous makes on the market and all are good. The chief thing is for the photographer to know how to use the one he has and be able to guarantee results. Practice is obviously essential.

The taking of the photograph.

10. *The time of day and point of view.*—Most silvicultural subjects include a number of trees or plants at varying distances from the camera. If these are to show up well in the photograph one side of each tree should be in the sun and one in the shade and this can be achieved only when the sun is fairly low and if a view-point is selected with the sun well to one side.

If possible photos should be taken before 10 A.M. or after 4 P.M.

It sometimes happens that one wants to photograph an immovable object from a particular spot and that the sun is in the wrong position when the place is first visited. In such cases, if time is available, it is well worth while calculating with a compass at what time the sun will be right and then returning to the place to make the exposure.

11. *Composition of a photograph.*—This note is not a dissertation on Art, so all that will be said on this subject is that if there is only one principal object in the photograph it should not be in the exact centre while if there are two or more some attempt should be made to 'balance' them.

12. *Scale.*—All forest photos should include some object by which the size of the object being photographed can be judged. A human being, a walking stick or, in the case of close-ups a section of a measuring tape are suggested.

13. *Focussing.*—Forest subjects can be divided into two main types as regards focussing :—

(*a*) those in which all detail should be equally sharp ;

(*b*) those in which it makes for clearness if only the principal object or objects are sharp while the remainder of the photograph is out of focus.

Nothing need be said about the entirely sharp type except that a small stop (say f/16) must be used and the exposure calculated accordingly.

When only one object is to be sharp, differential focussing must be employed and the photographer must try different stops at the same time examining the results on the ground-glass to decide which stop suits his purpose best.

Differential focussing is invaluable on a sunless day as it is the only possible method of showing perspective.

Treatment of exposed plates or films.

14. The writer is strongly in favour of developing in the jungle. In Burma at all events professional photographers to whom exposed plates could be sent are few and far between, and even if plates are sent to them the odds are on their being scratched, damaged irreparably by finger-marks or improperly washed.

Apart from better work other advantages of developing oneself are (*i*) that one can see results and possibly retake unsuccessful photos ; (*ii*) that all plates and films in the rains and panchromatic plates at any time should be developed as soon as possible after exposure.

The writer uses a tank and the time-and-temperature method for developing plates, and dishes and the visual method for films. Rytol has been the developer used for many years. For a dark-room lamp an electric torch with two discs of non-actinic fabric inserted under the glass is most satisfactory.

Hardener should invariably be used before development as, if plates are hardened, developing can be done with water at practically any temperature and the drying period, which is very dangerous when dust or insects are about, can be shortened enormously and the film is rendered almost uninvulnerable to damage by moulds, etc., when stored in due course.

A concentrated solution of hypo (acid hypo in the case of films) should be kept ready-mixed and be brought to the temperature of the water to be used for developing and washing. This is because (for some reason unknown to the writer who is no chemist) freshly made hypo makes the water in which it is dissolved much colder than it was before.

If "frilling" of the negative is to be avoided all the solutions in which negatives are placed must be approximately the same temperature.

15. ***Washing*** **is the chief difficulty of developing in camp and unless there** is plenty of clean water available, say, ½ dozen kerosine-oil tins full, developing definitely cannot be done. Assuming that such a quantity of water is available the writer has found that the best washing-vessel is a kerosine oil tin (which is free from rust) with a few small holes punched in the bottom of it.

If plates are used the whole rack containing them is placed at the bottom of the tin, while if films are used they should be cut into strips shorter than the height of the tin, each strip then being suspended vertically in the water.

The operation of washing then consists of a servant keeping the water up to the top with the household bath mug while master sits back with a well-earned pipe and organises the water reserves. Washing should be carried on for at least half an hour.

16. ***Drying*** is accelerated considerably if surplus water is wiped very carefully off the negatives with well-washed and non-gritty fingers. If the negatives have been really well hardened they can then be dried either in the (not too hot) sun or reasonably near a fire or lamp.

Don't alter the rate of drying of a negative in the middle of that process.

17. *Printing.*—The important part of the result, *i.e.*, the negative, having been obtained printing can generally be left until one returns to headquarters. It is useful, however, sometimes to be able to do a print at once, and for this purpose a packet or two of self-toning paper and a printing-frame can be included in the kit.

18. *Enlargements.*—The making of enlarged negatives or prints is generally best left to professional photographers.

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PAPER (II).

Contributed by M. V. Laurie, *Silviculturist, Madras.*

Preparation of a photographic manual.

Points with which such a manual should deal with are :—

(1) *Apparatus*—suitable types of cameras stands, lenses, etc.

(2) *Materials*—best kinds of plates and films to use, etc., for particular subjects, including use of filters. (Trials by Central Silviculturist of different filters—*e.g.*, green filters covering a very narrow spectral band—for getting differentiation between varying shades of green so as to be able to distinguish foliage of different species when mixed up together).

(3) *Actual field work.*—Best kind of lighting for different subjects.

Selection of view point.

Exposures.

Exposure meters and tables.

How best to deal with difficult subjects.

Excessive contrast, halation, insufficient contrast, movement, etc.,

Particulars that should be recorded for the titles of silvicultural photographs.

(4) *Development and printing*—with special reference to tropical conditions (tests with developers for work at high temperatures to be made by Central Silviculturist with different materials), papers and printing methods to use in order to get permanency under tropical conditions, etc.

(5) *Stereoscopic photography*—its uses,—apparatus required—(special stand head for single lens cameras, etc.), its limitations—best sizes to use—best methods of presentation. (Trials to be made with anaglyphs—transparencies on diapositive films, etc.)—best types of apparatus for viewing stereo photographs.

(6) **Silvicultural Photo collections and records—methods of keeping print and negative collections—negative storage and preservation—methods of mounting and titling prints—indexing and referencing, etc.**

The above points are just jotted down on the spur of the moment, and lay no claim to completeness. Other chapters might deal with Lantern-slide production, Cinema photography, etc.

The book should not replace any of the standard photographic text-books but deal with photography from the special view point of silvicultural research officer. A full bibliography should be included. Mr. F. W. Champion could doubtless provide much valuable information,—and might be the most suitable person to write the book—at any rate the technical portion. Mr. Seaman might also be of assistance.

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PAPER (III).

Contributed by E. C. Mobbs, *Silviculturist, United Provinces.*

Forest photographers can be divided roughly into two classes. Firstly, there is the large body of camera owners, who do not know much about photography, and whose chief concern is with the exposure ; developing and printing are usually left to other people. Secondly, there are the more serious photographers, among whom all Silviculturists should be included, who go more deeply into the question of cameras, plates, filters and other matters affecting exposures, and who also are concerned more intimately with the developing and printing of their own exposures, and sometimes also of other peoples.

Both classes probably feel the need of a manual of photography, but they do not require the same information. In dealing, therefore, with the question of a manual of forest photography, it is necessary to decide first of all whom the manual is intended for. It will probably be generally agreed that in the first place the manual should be for the serious and would-be serious photographer. But the first class of ordinary photographers should also be catered for. They have numerous opportunities of taking photos that a Silviculturist cannot obtain. As it is they often produce quite good photos, and with a few hints and a little information to enable them to make better use of their cameras, they could contribute very valuably to a provincial collection of forest photos.

I suggest, therefore, that in the first place a fairly comprehensive manual of forest photography be compiled, and that then a brief summary of points of interest to ordinary photographers be issued. The latter would definitely avoid anything liable to confuse, and would contain information applicable to the ordinary folding camera, and to the common makes of roll film, film pack or plates, and might also contain a little additional elementary information on such subjects as exposure meters and their uses, stops and their uses, etc., which might not appear in the detailed manual.

I have drawn up a list, as an appendix to this note, of the points which I think should be dealt with in the manual. But these are only the points on which I personally feel need of information. Others will probably not feel the need of information on all these points, but may require information in other directions.

I suggest, therefore, that one officer, preferably the Central Silviculturist, be nominated as the compiling officer, and that all Provincial Silviculturists and any others interested in photography who may so desire submit to him lists of the points which they consider should be dealt with in the manual, grouped under convenient heads. The compiling officer should then amalgamate all these lists and circulate the final list. All Silviculturists and others who have sent in suggestions should then write brief notes on as many of the points as they can, based on their own experience. The compiling officer would then amalgamate these notes and supplement them with notes from standard works of reference and if necessary with notes from manufacturers of photographic materials.

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Item 1 (d).]

Appendix.

Points to be dealt with in a Manual of Forest Photography.

Light conditions in the forest. The difference in actinic value of light at different times of the day compared with light at midday under different conditions of shade.

Plates and films. Comparison of speeds, grain and hardness of film of different makes. Recommendations as to best plates or films for different classes of photography.

Exposure meters. Different makes and suitability for forest work. Allowances to be made for various types of work.

Stop and Exposure. When to choose between a small stop and a long exposure and a wide stop and a short exposure.

Exposure. When deliberately to over expose or to under expose.

(*e.g.* When a photo has to be taken in fairly open forest at midday, it might be advisable deliberately to over expose the plate, so as to make sure of getting the details of the shadows, and then to reduce the high lights after development.

On the other hand, when photographing a single tree against the sky, it might be better sometimes deliberately to under expose, so as to get a silhouette of the crown form.)

Filters. Grades by different makers and their uses with various kinds of plates or films. When it is better not to use a filter, and when to choose between different grades.

(*e.g.* For some views I have used a red filter with a panchromatic plate, involving 24 times the normal exposure. If trees in the foreground are to be silhouetted, this is quite suitable. But if details of forest or trees are required, a much milder orange or yellow filter would be better.)

Development. Relative effect on various types of plates and films. Use of desensitisers.

(This I consider very important. Often one has no option in the matter of time of day or lighting conditions in taking a photo, and one knows beforehand that the plate will be definitely either flat or over exposed. Much could probably be done to help matters if one could choose a developer that will either enhance contrast, or will soften contrast, as the case may be.)

Improving the negative. Intensification, clarification and reduction. Types of reducing agents and their relative effects.

(*e.g.* In lantern slide making, I nearly always clarify the plate in a weak reducer, and sometimes intentionally over expose or over develop to permit this.)

Printing papers. Types of papers and their speeds. Effect of speed on nature of print. Suitability of different papers for different subjects, and for different grades of negatives.

Development of gaslight and bromide papers, and of lantern slides. Comparison of different developers, with special reference to enhancing or softening contrast, and bringing out of detail.

Toning—toning agents and their effect ; value of toning.

Notes on colour photography.

Notes on Cinematography.

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Note by Mr. E. W. Carroll *on Mr. Mobbs' paper on the proposed Manual of Photography.*

Personally I am not in favour of producing a comprehensive manual as he suggests. There must already be in existence standard works on photography which are brought up to date at frequent intervals by experts and which contain information on all or nearly all of the branches of the subject mentioned by him. Such standard works would be considerably more attractive, comprehensive and up-to-date than a departmental manual would be a couple of years after it had been printed. I suggest that each Silviculturist's library should include one or two of such standard works and also several more elementary books. The Silviculturist could lend these out at his own discretion to people interested.

What I think our manual should consist of is a series of notes on points in connection with which, owing to existence in India and to touring in the jungle, our practice must differ from practice in more civilised surroundings. To that end I suggest that one or two of the better class standard works be taken, and that

(*i*) a list should be made of the various subjects dealt with, including, of course only such subjects and such details that are of interest to a forest officer in that capacity.

(*ii*) Against each of these subjects it should be recorded in separate columns—

(*a*) whether the notes in the books apply to India generally or not ;

(*b*) whether they apply to a touring forest officer or not.

Our manual should then, to my mind, consist of comprehensive practical notes on the subjects and details against which "No" had been recorded in Cols. 2 and 3 of the list, and also of information on points of interest not recorded in the original books.

2. I am going home on a year's leave very shortly and if I can be of any assistance in the way of selecting books on Photography in England I should be delighted to do so.

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PAPER (IV).

Contributed by H. L. Wright, *Conservator of Forests, North-West Frontier Province.*

The first point to be considered is whether the manual is to be a self-contained treaties on forest photography or merely supplementary to existing handbooks.

There are so many good handbooks on photography already in existence that it seems unnecessary to add to them and for this reason a comparatively short pamphlet dealing with the special aspects of forest photography is probably all that is necessary.

This should suggest the most suitable types of apparatus,—cameras, stands, lenses, filters, etc.,—and of materials,—plates and films,—for forest work, and should also give hints on such subjects as lighting, stops to be used and exposure.

As regards exposure and photographic processes in general, one of the best guides for the ordinary worker, rather than the expert, is the Wellcome Exposure Calculator, Handbook and Diary. This might well be adopted as the standard book to be used and the manual could then give any supplementary information required, such as a special Exposure Table A for forest subjects.

All that is required of the worker in the forest is to be able to make negatives suitable for producing enlargements which will show what they were intended to show, and there seems no need therefore for the manual to go further than the production of the negative. Prints and enlargements are usually much better produced by the professional.

An important section of the manual will be that dealing with titling, the information to be recorded and the formation of silvicultural photographic collections. It is a matter for discussion whether all provincial collections should not be formed of prints of a uniform size, *e.g.*, half or full plate enlargements, and printed in a uniform process, *e.g.*, glossy bromide.

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Item 1 (d).]

PAPER (V).

By E. O. Shebbeare, *Conservator of Forests, and* W. E. Hodge, *Deputy Conservator of Forests (Bengal).*

It is suggested that the proposed manual should be as simple and as non-technical as possible. The following suggestions for headings are put forward :—

(*a*) Brief description of various kinds of cameras, with the advantages and disadvantages of each. Reflex, Leica, Stereoscopic, &c.

(*b*) Brief description of types of lenses, with advantages and disadvantages. Wide angle, large aperture, etc.

(*c*) Types of shutters with advantages and disadvantages. Focal plane, compur, &c.

Difference between lens and shutter speeds.

Large opening means loss of focal depth.

Systems of marking openings—U. S. and *f*.

(*d*) Plates. Advantages and disadvantages of panchros. Cut film v. plates. Film packs. Non-halation plates, &c.

(*e*) Colour filters, sky filters and their uses.

(*f*) Enlarging if a small camera has to be used.

(*g*) Development. Temperatures, difficulties of developing in the hot weather. Emulsion hardeners, tanks, intensifying.

(*h*) Common troubles. Pin holes in bellows.

Ground glass focussing screen the wrong way round.

Fungus on lens. Diaphragm shutter rusty.

Plates damaged by damp and heat.

(*i*) Exposure meters, notes on exposures, lighting, best time of day, etc., for forest photographs.

(*j*) Printing, retouching, etc.

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Note on papers (ii) and (v) by F. W. Champion, *Deputy Conservator of Forests, United Provinces.*

I doubt if a photographic manual is really necessary, considering the numerous admirable manuals that are already on the market. A publication like the '*Dictionary of Photography*' deals with 95 per cent. of the subjects required, and many of those listed are the mere A. B. C., of photography and hardly require to be printed in a special manual, as presumably any one who wants to take photographs must have some idea of the subject.

Certain difficult points, such as hot weather development and special light filters, might require special mention, but a complete manual seems to me somewhat superfluous.

If however a special manual is considered necessary I shall be only too pleased to co-operate, even to the extent of writing it, if so requested—but such a manual would require a good many diagrams and illustrations and would be expensive to produce.

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Extracts from remaining notes submitted.

(*i*) *Silviculturist, Bengal.*—" A Photographic Manual is absolutely necessary. It should be as non-technical as possible ".

(*ii*) *Silviculturist, Central Provinces.*—A Photographic Manual for forest use would be most useful : it should be of an elementary nature, as few forest officers are expert photographers and those who are experts would not be in need of such a manual. I would suggest that a draft should be prepared at Dehra Dun and that each province should nominate one officer, interested in photography, who should be asked to scrutinise the draft and to offer suggestions for alterations, before the manual is published.

(iii) Forest Research Officer, Bihar and Orissa.—A Manual of Forest Photography would certainly be valuable.

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Report of Debate.

Mr. Shebbeare : Gentlemen, I want to ask for suggestions more than anything else. I have had notes written by about five people but the point we want to deal with is what are most important things to be included in the Manual. Mr. Laurie and Mr. Mobbs are both here and I will ask them to tell us what their views are as to what should be included in the manual.

Mr. Mobbs : There is considerable difference of opinion as to what should be included. One note from Burma says that a full plate camera is as dead as a dodo and should never be used. I don't think so myself. I think this conference if it begins to discuss what should be put in a manual will never finish. What I think should be discussed is how a manual should be compiled and then when we have discussed the methods of compilation, leave it to those people who do the compiling to decide for themselves as to what should be put in the manual

Mr. Laurie : I agree with what Mr. Mobbs has said. I think the best way of compiling this manual would be to circulate a skeleton outline to everybody interested in forest photography and to get their ideas regarding what ought to be put in each chapter and also to add every kind of useful tip. The information should then be returned to the Central Silviculturist who would either himself compile the manual or depute somebody else to do it after deciding what should be included and what should not be included. Regarding the scope of the manual, I think that it ought to be for the would-be serious photographer. There would possibly be in an appendix or a special chapter dealing with the difficulties of the ordinary camera owner who does not intend to be serious but who gets his films developed by the local photographer.

Mr. Mobbs : I made a suggestion in my note and it has been made to me just now, *viz.*, that the manual of photography will only be required by a few serious people. There are large number of people who take photos who do not want a big manual of photography. If we put a preliminary chapter in front for their use we shall give a whole lot of information that will be wasted. I think, therefore, the better plan will be to have a separate bulletin or leaflet for the amateur and a separate detailed manual for the serious photographer. I think, therefore, that our resolution might say something to this effect, that this conference realises the necessity of a manual of photography both for the amateurs who are very numerous in the forest services and for the few serious photographers, and we should take steps to compile and publish separately general information for the inexperienced amateur, and detailed information for the more serious photographer.

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Note on Photographic Exhibit.

An exhibit was arranged in the Forest Botanist's office to illustrate the subjects which might be dealt with by the proposed Manual. Material was contributed by Mr. E. C. Mobbs, Mr Bhargava, and the Central Silviculturist, and arranged and explained by Mr. Mobbs.

The exhibits dealt with the following subjects :—

1. Use of small cameras such as the Leica and subsequent enlargement from the film.
2. Comparison of panchromatic and orthochromatic plates.
3. Comparison of plates, backed plates, and film particularly as regards halation effects.
4. Stereoscopic work including instruments, prints and transparencies.
5. Colour photography—Agfa and Finlay processes.

6. Choice of printing paper to suit a negative.
7. Details in printing and enlarging work to reduce effect of defects in the negative.
8. Use of diaphragm in taking photographs.
9. Effect of angle of view in taking photographs.
10. Exposure meters.

Note on Cinema Exhibition.

The following forest films were exhibited in the Board Room on the evening of October 31st, Mr. Laurie being in charge of arrangements :—

1. *Timber extraction*—(by tractors, elephants and man power) Chittagong Hill Tracts—by R. I. Macalpine.
2. *Raising a Teak Plantation*—South Coimbatore Division, Madras--by M. F. Bridge.
3. *Telescopic Floating*—(Deodar sleepers) from Punjab Silviculturist.
4. *Shikar Scenes in Nepal*—by Wrangham Hardy.
5. *Jungle, Shikar and Village Scenes in the United Provinces*—by D. Stewart.
6. *The Sunderbunds* by E. O. Shebbeare.
7. *Tractor logging* (American)—D. N. Murty Rao, Forest Engineer, Bhadravati, Mysore.

In addition, Mr. Shebbeare shewed the well known film of a fight between a cobra and a mongoose entitled "*Killing the Killer*", and some films of climbing in the Tibet Himalaya.

ITEM 2.

Howard's filing system in Silvicultural Offices.

Proposals for addenda or corrigenda to the existing system or improvements in the method of printing were called for. Notes (p. 52) were submitted by Bihar and Orissa and the United Provinces and a summary was circulated by the Central Silviculturist (p. 53).

These notes mainly expressed a demand for a redraft and extension of the heads 8 and 9 (*Extraction* and *Utilisation*). The United Provinces considered that the main heads under 9 should be drastically rearranged while Bihar and Orissa particularly felt the need for a complete revision and expansion of subhead 94. Both provinces submitted draft suggestions.

The Punjab reported that subhead 1213, *Afforestation of Arid Areas* required considerable sub-division for which a draft was submitted.

The Central Silviculturist also reported that a system of arranging and numbering papers on the specific and general ledger files has become very necessary at the Forest Research Institute.

A Committee consisting of Messrs. Howard (*Chairman*), F. C. Osmaston and E. C. Mobbs considered reclassification or rearrangement of heads 8 and 9. Their report was made by Mr. Howard who opened the debate (p. 54) on the subject.

Mr. Champion explained how the provisional classification of heads 8 and 9 had been arrived at and the practical reasons why in certain respects it departed from the general principles of the system. He stressed that it was not designed for or applicable to the detailed records of a Utilisation Officer which is so much concerned with commercial matters not provided for under the silvicultural scientific heads for which the system was developed.

The following resolution was proposed by Mr. S. H. Howard (United Provinces) and seconded by Mr. F. C. Osmaston (Bihar and Orissa). It was passed unanimously.

RESOLUTION ON ITEM 2.

Resolved that—

The report of the sub-committee be accepted. As the subject is too complicated to settle in the time at the disposal of the conference it is suggested that the existing scheme be continued till a better is evolved, but that Dehra Dun, local silviculturists and utilisation officers should attempt by mutual agreement to evolve such a scheme, and when evolved, it should be adopted. It should be shown for information at the next conference.

Abridged Report of the Sub-Committee.

If the committee had attempted in the time at its disposal to work out a classification for these heads, 8 and 9, we should have got into exactly the same difficulties as are already being experienced. We therefore have not attempted to make out such a classification or to incorporate suggestions that have been made. We do not consider the conference should pass any resolution on this matter, but we recommend that the whole of heads 8 and 9 be reconsidered by officers dealing with utilisation. [*cf.* p. 54].

Report of the Silviculturist, Forest Research Institute, on action taken on the Resolution passed by the 1929 Conference.

The 1929 resolution was as follows :—

Resolved *that this Conference recommends the adoption of Howard's Filing System for Silvicultural records in all provinces, with the proviso that it should not of necessity di*

the detailed recommendations of the Committee in the appended report.

Item 2.]

Resolved that—

Report of the Committee.

The Committee accepts the conclusions reached in the Central Silviculturist's paper with slight modifications. The recommendations then stand as follows :—

1. Howard's Filing System should be adopted for Silvicultural records in all provinces. It should not, however, necessarily displace an equally good system already in use.
2. Further sub-division when needed should be effected under the arrangement described in the above quoted paper paragraph 5*.
3. Alterations, if any, should be made by the Central Silviculturist with the agreement of the majority of Provincial Silviculturists.
4. New editions of the Classification and Index should be printed from time to time whenever the number of correction slips becomes inconveniently large.

The Government of India accepted the resolution.

The northern provinces have been most interested, *viz.*, Punjab, United Provinces, Bihar and Orissa and Bengal. Four editions of the System and its Index have been issued since the 1929 Conference and some heads are still under correspondence. Proposals for amendments and additions have been received from time to time by the Central Silviculturist and settled after correspondence with those concerned. It has been found necessary to include provisional subdivision of the *Extraction* and *Utilisation* heads to make the system cover Libraries and Photo Collection.

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Note (i) by the Forest Research Officer, Bihar and Orissa.

The method of printing seems generally suitable, and I agree with the separation of the index of Extraction and Utilisation heads from other heads at present. When the index for these two heads becomes more comprehensive and the classification more settled, they may perhaps be more conveniently combined, but not till then.

I have not found any errors in the Specific and General Ledger Heads and am satisfied with them and the index except for heads 8 and 9 (Extraction and Utilisation), and these are admittedly '*in embryo*' at present. Although these heads do not perhaps interest Research Officers of Provinces other than Bihar and Orissa, I think these 2 heads should be put on a sound basis soon.

For the main head 8—Extraction I have no criticism. The subdivisions so far made seem sound and cover the needs of this province so far. The main subdivisions of 9—Utilisation also seem sound and it is the sub-head 94—Industries that I have found inadequate. Correspondence on this is in progress with the Silviculturist. It has been agreed that a truly logical subdivision of heads is next to impossible and that adequate use of the index is the only satisfactory solution. I have submitted a draft classification for consideration.

Other heads such as 97, 98 and 99 (embracing minor forest products) may also require subdivision but the need of it has not yet been experienced in this province, and changes need not yet be made.

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Note (ii) by the Silviculturist, United Provinces.

In the United Provinces, Howard's Filing System has been adopted since its inception for both Specific and General Ledger files. It was not, however, till 1932, after the abolition of the Utilisation division, that the Silviculturist took any interest either in extraction or Utilisation (Heads 8 and 9 of General Ledger Files). In the last two years a considerable number of papers have been collected for these heads, and under Utilisation in particular, some difficulty has been frequently felt in classification. Various points have been dealt with in correspondence, and recently the Silviculturist, Bihar and Orissa, has put up further modifications, on which the U. P. has expressed its opinion. It is not proposed to deal again with these points, but there is one main new suggestion that I would like to put forward.

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*Authority for the adoption of further sub-division should be vested in the Central Silviculturist. Whenever a provincial officer proposes to sub-divide any sub-head, recommendations should be sent to the Central Silviculturist, and he could accept them as received, or negotiate amendments if he thought desirable, particularly if other proposals had been received from another province.

Under the present classification, main sub-heads 91 to 96 deal with major products, and main sub-heads 97 to 99 deal with minor products. We have found in the U. P. that many of our papers on Utilisation subjects cannot be put in any one main sub-head, owing to their comprehensive nature. Consequently, it is either necessary to put such papers under the main head 9, or to put them in one or other of the main sub-heads and put cross references in the other main sub-heads concerned. Where more than one such cross reference is required, it is more convenient to put the paper under the main head 9. This means that the main head 9 contains a large number of general papers dealing with both major and minor products. It would be far more convenient if we could have all general papers on minor products separated from major products, and for this I propose a change in the main classification as follows :—

9 Utilisation.

91 Timber.

92 Fuel, Wood Distillation and Paper Pulp.

93 Minor Products.

Further subdivision would then proceed as at present, with such modifications as may be approved after discussion of the proposals put forward by the Silviculturist, Bihar and Orissa, and further suggestions based on them. Thus under head 93 we should have :—

931 Minor Products—Vegetable,

932 Minor Products—Animal,

933 Minor Products—Mineral,

in place of the present heads 97, 98 and 99, with the same sub-divisions as at present. Any paper dealing with Minor products in general, would then go to head 93, instead of to head 9, which would keep head 9 within reasonable proportions.

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Note (iii). Summary Note by the Silviculturist, Forest Research Institute.

Howard's system has continued in use in most provinces and at the Forest Research Institute. The subject classification and index have been expanded from time to time to meet new requirements and four revisions have been issued. The organisation for this work has proved satisfactory, provinces making the suggestions to the C. Silviculturist who corresponds with the other provinces concerned and finally decides on the most satisfactory solution.

2. There has been a demand for the expansion of the *Extraction* and *Utilisation* heads left blank by Howard. This has come from provinces where the research officer deals with both silviculture and utilisation (Bihar and Orissa, Punjab), and from other provinces where the classification is needed for libraries and photographs, (United Provinces). Several drafts have been considered and a scheme with separate index is included in the last revision, but there is a feeling that it could still be improved ; it is hoped that a committee will be able to settle this at the conference.

3. A point of general interest has also been raised by the Punjab which needs a decision. There the subhead 1213. *Afforestation of Arid areas* is very important and requires considerable subdivision, in fact a draft for this has been agreed on. This subdivision however duplicates a whole series of the subheads of 123 *Artificial regeneration* and so the routine procedure will involve duplicating all these in the Index for the two heads 123 and 1213. As the same potentialities exist locally for many other subheads, it is questionable whether it is advisable to increase the bulk of the index if an alternative can be agreed on.

4. A system of arranging and numbering papers on the specific and general ledger files is becoming very necessary at the F. R. I. It seems impossible to keep the files weeded and summarised without a whole time secretary for the work.—*H. G. Champion.*

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Item 2.]

Report of Debate.

Mr. Howard : A subcommittee consisting of myself, Mr. Mobbs, and Mr. Osmaston were told to look into the filing system with the idea of considering a classification for heads 8 and 9. These heads were originally left blank in the classification to serve as the main numbers from which to begin the classification of all work connected with the utilisation side of forestry. I may say that the original classification took me five years to complete and although the first draft was completed very quickly the rest of the time was spent in testing and altering. It sounds incredible that it should be necessary to take such a time to do a piece of work of this sort. I can only say that all those who have really tried will bear me out that it is very difficult to make up one of these classifications without falling into all sorts of traps which get one into difficulties later. Perhaps a fairly obvious proof of this is that before my classification there had been several carefully thought out attempts on this subject and when I began to take this matter up a very short examination showed where each one of these must have broken down. The work under " Utilisation " although it only starts from two numbers, is an even bigger and more difficult classification than the one I attempted, and therefore it would obviously have been quite impossible to expect a committee even to begin to deal with it in the few odd hours between the sessions of this Conference. Actually however there is in the present classification a start already made which was I understand the result of careful consideration between Mr. Champion and certain utilisation officers. All we were directly asked to do was to see whether certain suggestions which had been made about the utilisation heads could be usefully incorporated or not. The only suggestion which has been put on the papers supplied to me is one, which I can sum up by saying it was to use a rather larger head at the second digit so as to make a bigger opportunity of splitting further on. This splitting up became necessary because as it stood, there were certain papers covering a rather wide general subject (minor products to be exact), which at the moment was causing difficulties. This difficulty occurs in all these systems when there are general papers and the main heads are not made wide enough to take such general papers. Actually the individual suggestion was not worked out to its logical conclusion, as the attitude was to make three necessary main heads at the second digit and then to say that we should then carry on as already in the classification. May I say now once for all that if anybody ever puts up any suggestion to combine or split any head or subhead in this system it should not be considered by anyone until they have themselves written out exactly how that portion of that system will look after the change and including any alterations it will entail in further subdivisions of the same heads. I should like to add that this sort of thing caused endless trouble before it ever appeared officially in a committee. In the past I have had suggestions of this sort which the authors had not worked out to a logical conclusion and I think the Central Silviculturist ought to make it a definite rule never to accept alterations unless they are put up complete with all that they entail. At any rate the moment we began actually to write out the classification under head 9, utilisation, as it would have become with this suggestion, we immediately found ourselves getting into various difficulties merely because the original proposal had not thought out what it entailed. Knowing exactly that difficulties do occur over this system and knowing from past experience how impossible it is to do even one subhead in a hurry, I and my committee came to the conclusion that it would be ridiculous for us to attempt to sit down and draft a classification under head 9 in the time at our disposal. I fully admit we could have written down something, which when put up would probably have been passed as it would have looked all right, but we all have enough experience of this, and I hope Mr. Champion will bear me out, that although it would have been passed in full conference, such a hurriedly compiled thing would undoubtedly have led to difficulties later. In fact it was perfectly obvious where the difficulties were going to occur the moment we started.

There is also a proposal to reclassify the whole of the present head 94 Industries, which quite obviously is not very well done at present. Actually that proposal though written out is not entirely agreed to by all officers who are dealing with it. My committee take therefore exactly the same attitude as we have taken on the more general proposition, that is we say definitely that although a committee can criticise a finished scheme put before them, they can not even begin in the time to settle differences of opinion which have not yet been settled between the officers concerned especially when the authors themselves say that they have not really finished their discussions and can themselves improve on that they have proposed. If you will look at the present subdivision under heads 8 and 9, you will find some fairly obvious points which are bound to lead to difficulty. The main principle is that at each subdivision of a digit the heads under that subdivision should be of equal size. In actual fact if this were carried out logically, it would lead to a purely dichotomous subdivision and would end by a terrific string of numbers. A compromise is therefore made and unequal subheads are put at corresponding digits in order to avoid getting into difficulties. It is in practice most unwise to fill up all the numbers at any given subdivision if the subheads are of equal value. It is perfectly obvious looking at the subdivision under 8 and 9 that they are not merely of unequal value, but that they are not even logical. For example there is no head *Timber*, there is no head *Minor products*. There are however heads which would ordinarily be subdivisions of the timber head, namely things like properties of timber and preparation of timber, and there are already heads which would ordinarily be subdivisions of a minor forest products head such as for instance wood distillation and paper pulp. But while that occurs at the two digit division there are three minor product heads in the two digit division further on. Without going any further into the matter it is perfectly obvious to anybody who has dealt with these classifications that that alone is almost bound to lead to trouble. At the same time however, with these unequal heads, the whole of the 9 digits at the second subdivision have been filled up. Now although the compromise which we have to adopt does permit the making up of unequal subheads at a given subdivision, it is almost certain that under such circumstances it must be so arranged that certain digits are left blank till you are quite certain that difficulties will not arise. In actual fact the very proposals that have been put up for alterations are quite obvious in principle and are exactly the difficulties that one would have expected from the existing classification. Under head 8 the same thing has been done, but there luckily there are two blank digits at the second place, so that if difficulties arise there, they will probably be very much easier to correct. Our recommendations are summarised in our abridged report. If the committee had attempted in the time at its disposal to work out a classification for these heads, 8 and 9, we should have got to exactly the same difficulties as are already being experienced. We therefore have not attempted to make out such a classification or to incorporate the suggestions that have been made. We do not consider the conference should pass any resolution on this matter, but we recommend that the whole of heads 8 and 9 be reconsidered by officers dealing with utilisation.

If the classification is urgently required, we suggest that the authors of the suggestions obtain the collaboration of utilisation officers and write out their suggested subheads complete and then put it up for criticism. Even if it eventually proves wrong it can always be modified at a future conference. (No formal report was handed in by the Committee but Mr. Howard's address represented their joint views and the "abridged report" is taken *verbatim* from the later part of the address—*H. G. C.*).

Mr. Champion : There are one or two points which Mr. Howard has referred to on which comment by myself, who am responsible for the issue of our present classification, is called for. We only introduced heads 8 and 9 in the fourth edition of the scheme and the index. The pamphlet is still headed "Classification of Silvicultural Ledger Files with General Index", the point being that it has developed out of the experience of silviculturists who are forced to deal with records which are not silvicultural, in particular provincial libraries and photographic collections and sometimes one or other two minor items. At the same time one or two of the provincial silviculturists are also utilisation officers and actually it is they who have pressed for something to get on with.

Now directly we took up this problem we found that the detailed classification adopted by the Forest Economist at this Institute was not suitable for our requirements, mainly because he has to deal with very different subjects such as marketing and commercial matters generally, which have hardly any points of contact with silvicultural work.

When Mr. Howard first brought up the important point of equality of heads, he rather gave the impression that there is only one possible subdivision on these lines. That is purely a matter of opinion. There is no logical division of subjects into equal heads, with very rare exceptions. Granting this, as he did later, Mr. Howard said the other point to which we should pay attention was that of keeping free digits in reserve. There are two answers to this. Firstly, one which I think has been admitted by most of the authorities who have been referred to on the subject—that in the earlier stages of developments and in the earlier stages only, one can foresee all requirements. Now what we were out to do here was to limit ourselves to the earlier stages, because we were not providing for the whole variety of records of a Utilisation Branch—but only general subjects. We have good many years' experience, more than the five years which it took Mr. Howard to make the start, and we have a fairly large collection of records which should be classified. Now all these proposals were tested on all the available material including all the books in the Central Library of this Institute, and some of the modifications that have been put up have actually been the result of that check. The second point is the question of piling up of reference digits. There is no reason why with our intellectual development we cannot deal with three things simultaneously almost equally well as with two, and it often occurs that subdivision into three or four equal heads appear more logical than dichotomous division—thus *Minor Forest Products* into *Animal, Vegetable* and *Mineral.* The objection to the absence of a *General Minor Forest Products* head is on the face of it a sound one. As a matter of fact, the anticipated difficulty only came up with one or two books because it is unusual to have papers dealing with minor forest products generally. We therefore decided that rather than pile up digits, we would put in the three main divisions as equal heads using some of the spare digits under subhead 9 and so saving one digit in all references. We also proposed to make the first head "*Minor Forest Products* (*General and Vegetable*) ". The finding of the record is the whole object of the scheme ; no matter what classification we adopt there will frequently be more than one possible place to file it. We are out to meet a particular problem, namely to find our records or our books with a minimum delay and the maximum certainty. Provided we can find the reference number easily in the index, we have really done what we are asked to do.

The objection of course would still remain that we might have difficulty in the further sub-division—but actually we are very unlikely to need further to sub-divide any " general " books, for any subdivision will fall logically under one of the Minor Products heads. This is admittedly a compromise and it gets a little way from the original scheme, but as far as we can see, it should not lead us into the difficulties forecast by Mr. Howard. I would like to repeat that the scheme as it is proposed is purely tentative and it has really only been put forward to meet an immediate requirement which has led to the Institute here being pressed to do something about it. But I would like, before I sit down, to say that I consider it impossible to apply the classification, as we have it, to a utilisation office in the same form as we require it for our other records. The matter obviously cannot be dealt with by a committee. I have had to deal with it for nine years and I know what it involves. I am for the moment satisfied with the scheme but I would like to support the whole of Mr. Howard's proposal because I think that is the only way of making improvements. The scheme we have put up is already being tried out in actual use and I think it is very likely now that in view of Mr. Howard's very valuable criticism of it, the two or three of us who are concerned will be able to improve on it. At the same time I am surprised that Mr. Howard did not mention that any scheme once introduced in a large office is absolutely impossible to change. In this connection I should mention that I have just heard from Professor Troup that the international classification we have long been awaiting may be expected shortly. If possible we should like to adopt any internationally accepted classification, but unless it conforms fairly closely to our present classification, we shall find it impossible of adoption.* I support Mr. Howard's resolution.

NOTE.—*Mr. Howard had earlier remarked that he had a certain amount to do with this international classification ; " it is a thoroughly good classification for the library and a thoroughly bad one for our other records as we have to go into much greater detail in our research work than in the library."

Mr. Champion also gave his opinion that the classification and proposals that come from Europe are often not suited to Indian requirements.

Mr. Howard : I agree that once a scheme is definitely adopted and you have begun to get records on it, you cannot change it. I also agree that the index is as important as the classification. The real point of the classification is that it distributes the records in subjects so that books and papers which are on connected subjects are close to one another in the records on the library. I would also like to add that although it took me five years to do the work, I did not even touch the index, which is in many ways as difficult a thing to do as a classification.

Mr. Champion : There is one thing on which the committee did not express an opinion, on which as the officer responsible for the index, I would like to have a comment. That is suggestion from the Punjab that in the case of irrigated plantations they need extensive subdivision somewhat on the general lines of our whole head of artificial regeneration. If I am required to do this it will complicate the index to a very considerable extent and I think unnecessarily. The alternative of subdividing most subheads under artificial regeneration to collect the records for irrigated plantations is equally unsatisfactory and would also involve numerous addenda to the index. Any suggestions on this point will be very useful. (No suggestion was forthcoming—*H. G. C.*).

I might mention one other point that comes up constantly here with a lot of miscellaneous records. I find it necessary to insist on looking at all such records primarily from the forestry point of view. We get a paper, say on seed selection in barley. Should it go under an agriculture subhead or under some forestry head ? As foresters, that paper is interesting to us for its bearing on forestry and it should go to the file 11244—a subhead of silviculture.

Mr. Howard : I believe I am right in saying that Mr. Mobbs in filing our records always attempts to put everything under a forestry head rather than under another head and he puts it under another head only as a cross reference.

Mr. Champion : Whenever possible, I avoid cross referencing by taking copies. Cross references are sometimes necessary and unavoidable, but they are extremely inconvenient and irritating. (Generally agreed—*H. G. C.*).

ITEM 3.

Silvicultural Libraries.

No papers were submitted and only one suggestion was brought forward by the Silviculturist, Bengal, which was adopted in the following resolution proposed by Mr. C. K. Homfray (Bengal) and seconded by Mr. P. N. Deogun (Forest Research Institute).

RESOLUTION ON ITEM 3.

Resolved that—

As difficulty is experienced in procuring copies of cheap foreign publications recommended by the Central Silviculturist, it is suggested that indents may be placed with the latter and that he should procure all copies on one order, the cost being borne by the actual recipients.

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Report by the Silviculturist, Forest Research Institute, on action taken on the resolution passed by the 1929 Conference.

The resolution which was accepted by the Government of India was as follows :—

Resolved *that the report of the Committee be accepted.*

Report of the Committee.

The Committee makes the following recommendations :—

1. A new catalogue of the Research Institute libraries is needed.
2. The Research Institute libraries should provide for issuing books on loan to forest officers in the provinces, particularly to research officers.
3. The Central Silviculturist should see to it that an annual list of important forestry publications added to the Research Institute Libraries is issued to Provincial Silviculturists. (Possibly a descriptive note might be added for each).
4. There should be one good library in each province. The Silviculturist should also have his own library with all Indian publications including selected working plans.
5. If the recommendation of the Empire Forestry Conference is acted on, that the Imperial Forest Institute should issue quarterly a publication on the lines of " Biological Abstracts ", all provinces should procure a copy of this publication. The Central Silviculturist should then intimate to Provincial Silviculturists the titles of books and papers available in the Forest Research Institute Libraries, and invite attention to those items which he might consider of special interest to each, adding such notes as he might think useful. The Central Silviculturist should further consider a scheme whereby each province might deal with 2 or 3 periodicals with a view to this annotation, such scheme to be circulated to Provincial Silviculturists for criticism.
6. The lists printed in the Central Silviculturist's paper should be revised and published for circulation.

The following action has been taken on the several recommendations :—

1. The new catalogue of the Forest Research Institute libraries is now under compilation.
2. Books have been issued on loan to Punjab, United Provinces and Bihar and Orissa.
3. An annotated list of new books has been issued by the Central Silviculturist annually.

4. Provincial libraries are maintained in each province usually under the charge of the Silviculturist. Bengal has had no funds to buy books for the last two years.

5. The Imperial Forestry Institute, Oxford, has not yet commenced issuing abstracts of Forestry literature though it is believed they hope to do so before long.

6. The lists were revised and issued with the Conference Proceedings.

The United Provinces, Punjab and Bombay have supplied a copy of their forest library catalogue to the Central Silviculturist.

ITEM 5.

Glossary of Technical Terms.

The Glossary was published as an Indian Forest Record in 1930. Proposals for alterations and additions were received from Assam, Bengal, Bihar and Orissa, Bombay, the Central Provinces and the Forest Research Institute. A summary was prepared by the Central Silviculturist and circulated before the conference. A committee consisting of Messrs. TREVOR (Chairman), SHEBBEARE (Bengal), VILLAR (Burma) and HOWARD (United Provinces) scrutinised these proposals and the chairman presented their report to the conference. The debate was very brief ; Mr. HOWARD referred to the value of standardised meanings for terms in use for fire protection operations but agreed that uniformity between provinces appeared impossible.

The following resolution was proposed by Mr. TREVOR, seconded by Mr. SHEBBEARE (Bengal), and passed.

RESOLUTION ON ITEM 5.

RESOLVED that—

This Conference accepts the alterations of the Glossary recommended by the Committee, and recommends that they be included in the next edition published, the necessary correction slips being issued meanwhile.

Report of the Committee.

A sub-committee consisting of Messrs. TREVOR, SHEBBEARE, VILLAR and HOWARD considered the proposed amendments to the glossary received and recommend that :—

1. Mr. HOMFRAY be asked to check the existing botanical terms and to suggest the inclusion of such additional common terms as he considers necessary.

(NOTE.—It is impossible to consider the inclusion of all botanical terms.)

2. *Ecological Terms.*—These may be included in an Appendix to the *Silvicultural Research Manual.*

3. *Utilization Terms.*—A selection of the commonest terms in every day use may be compiled for inclusion in the glossary.

4. The following terms be included in the glossary, with the definitions given :—

Close-season.—To be substituted for *close-time.*

Co-dominant.—Dominant trees which fall below the general top level of the canopy.

Commercial timber.—The volume under bark of the commercial bole.

Compartment History.—The record of all details of particular interest to an individual compartment.

Coppice with Reserves.—A modification of the simple coppice system in which for any reason trees or groups of trees of any size are excluded from clear felling. On page 44 of the glossary between the *Coppice with Standard* and *Selection Coppice Systems* insert as follows :—

System.	Regeneration.	Type or Crop.
The coppice with Reserves System	Mostly coppice	Evenaged except for the reserved parts.

Part of the crop is reserved for any reason for the whole or part of a second rotation.

The objects are to avoid cutting good immature timber, and to maintain a desirable species mixture, and the reserved areas are usually patches of good soil in otherwise inferior forest.

Cover crop.—A subsidiary crop of low plants introduced in a plantation to cover the soil between or below the main crop.

Final Yield.—Add the words ' *or from trees which have reached exploitable*

Item 5.]

***Fire trace.*—A cleaned (often burnt) line used as a base from which to** counterfire.

***Forest circle.*—A group of forest divisions forming a Conservator's charge.**

Forest division or district.—An executive unit under the charge of a divisional or district forest officer.

(*Hardy species.*—This term should be omitted.)

Irregular fellings.—Fellings not prescribed by a working plan, such as fellings for road construction, etc., when no provision is made for them in the plan, and illicit fellings. To be contrasted with unregulated fellings. (Fellings neither prescribed nor expressly permitted in a working plan).

Plantation Journal.—The record of all details of interest to a plantation.

Predominant.*—The taller dominant trees which determine the general top level of the canopy.

Pregerminated seed.—Seed which has been germinated by special treatment before sowing.

***Reduced area.*—Area to which a given tract of forest is equivalent in terms** of productivity on a selected standard.

Shade demander.—A species requiring at least in its early stages some degree of shade for its normal development.

***Unregulated fellings.*—Timber removed under prescriptions that give no definite yield either by area or volume.**

Whip.—Definition to be brought forward from Appendix II of the glossary.

Wolf tree.—Tree class I (*b*) 2—Badly shaped old advance growth—might be brought forward.

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*The classification of thinnings and the tree classification into crown classes—Appendix II of the Glossary—will not be altered by reason of including co-dominant and predominant in the list of technical terms.

ITEM 6.

Methods of Experimental Research.

(The Experimental Manual for Silvicultural Research.)

Notes were called for under a number of sub-heads of this item, several of which are dealt with separately below. In all cases, the decisions reached are ultimately to be incorporated in the *Experimental Manual.* A committee consisting of all Provincial Silviculturists (except Burma), sitting under the Chairmanship of the Central Silviculturist, considered in detail the proposals received on sub-heads other than those separately dealt with and a report was made to the Conference by Mr. H. G. Champion. The following resolution was proposed by Mr. Garland (Bombay) and seconded by Mr. Mohan (Punjab), and passed by the Conference without debate.

RESOLUTION ON ITEM 6 (General).

Resolved *that the recommendations of the Committee for amendments and additions to the Silvicultural Manual be adopted.*

Report of the Committee.

The Committee discussed all proposals which might necessitate amendments or additions to the *Silvicultural Manual, Vol. I* including several which are under consideration under other items of the Conference Agenda. The following recommendations are made :—

(*a*) *Assessment of Natural Regeneration.*—The amendments necessitated by the Resolution on Item 6 (*a*) should be incorporated in the Manual.

(*b*) *Soil Research.*—It is neither necessary nor advisable at present to re-write the section concerned (pp. 75—80) but the Central Silviculturist should have available for communication to forest officers in the provinces information as to approved methods of taking soil profiles, the field determination of pH values and the form, price and source of the instruments necessary for this work.

(*c*) *Root competition.*—A section should be added to the Manual dealing with the methods of investigation. A published summary of available information on the subject would be helpful.

(*d*) *Ecological Research.*—A glossary of ecological terms should be added as an appendix to the Manual. Information bearing on forest ecological studies should be collected from the available sources and published.

Methods of measuring light intensity under a tree canopy should be investigated and the results reported.

(*e*) *Regeneration of Tropical Evergreen forest.*—No addition to the Manual is needed at present.

(*f*) *Forest Grazing Investigations.*—No addition to the Manual is needed at present.

(*g*) *Research in Irrigated Plantations.*—Methods suited to this special subject should be considered by the interested provinces and the Central Silvi- but no addition to the Manual is needed at present.

(*h*) *Record of Expenditure on Experimental Plots.*—The separate resolution on this subject meets with approval and no further action is called for.

(*i*) *Research on mixture of species in plantations.*—The resolution on Item 23 calls for the publication of a summary of existing information and suggestions for lines of research. No addition to the Manual is needed at present.

(*j*) *Bamboo Investigations.*—The section (p. 96) on bamboo should be re-written with all necessary detail in the light of recently acquired experience in laying out experimental plots.

(*k*) *Statistical Analysis.*—(*i*) The two addenda proposed by Mr. Mahendru (see p. 115) dealing with the comparison between two counts or percentage values (as for two germination tests) and with the determination of the mean and its standard error when the data are arranged in groups, should be included.

(*ii*) The effects of working with small samples and abnormal distribution series should be further examined and the procedure recommended in the Manual be revised as necessary.

(*iii*) Acceptable short cuts in the computation of Standard Error should be described.

(*iv*) The method of allowing for initial differences in comparative pairs plots by maintaining them for a suitable period before introducing the different treatments to be compared, should be investigated, to meet the difficulty experienced in finding forest plots which will pass the recognised statistical tests for comparability.

(*l*) *Experimental Plot Forms.*—The front page of Form 6 is extensively used but should be improved on the lines suggested by Madras to meet requirements for artificial regeneration work. It should provide for entry of the essential compilation data for determining differences of mean values and their errors. The revised form should be referred to as 6 (*a*).

A new form 6 (*n*) should be standardised differing from 6 (*a*) on the front page only and adapted to requirements for natural regeneration. Information already on Form 3 should be excluded as far as possible and the right hand side of the form should be ruled vertically without headings. Drafts of these forms should be circulated by the Central Silviculturist for consideration and the form standardised as soon as agreement is reached.

Experimental Plot Form No. 8 (F. R. I. No. 148) should be revised on the lines approved by the committee.

Form 9.—Summary (Nurseries).

A form suitable for the record of the history of nursery beds and the raising of nursery stock is used in some provinces ; those concerned might usefully agree on a standardised form.

Form 11.—(Germination Tests).

A draft by the Central Silviculturist was approved after modification to provide for plant per cent. as well as germinative capacity and minor amendments.

Form 12.—Bamboo Experiments.

The possible advantages of using this in book form should be considered.

(*m*) *Phenological Records.*—A very simple form is required for collecting the essential data. Phenological data on important trees would be useful, and their collection is considered feasible. A further form may be needed for compilation purposes.

(*n*) *Canopy measurements in regeneration experiments.*—The number of trees and basal area for each species (or group of species when necessary) should be recorded. This note should be added on p. 114 of the Manual.

Report of the Silviculturist, Forest Research Institute, on action taken on the Resolution passed by the 1929 Conference.

The Resolution accepted the report of the committee on the subject, which recommended that the Central Silviculturist be asked to publish a manual of Experimental Research on the lines of a paper he had contributed to the Conference.

The *Manual of Experimental Research* was published in 1931 and has been largely followed in subsequent work. Some sections now require modification or amplification. An abridged edition for a wider circulation to Rangers and others has been called for. The Central Silviculturist visited the chief Research Institutes in Europe in 1931 and published an abridged report in the *Indian Forester* 1932-33.

ITEM 6 (*a*).

Method of Assessing Progress of Natural Regeneration.

Short papers (see pp. 67-68) were submitted by the Silviculturists of Bengal, Bihar and Orissa, and the United Provinces and the Central Silviculturist circulated a note (p. 68). Mr. Mobbs introduced the subject in the Conference [*cf.* paper (*i*) below] and the Central Silviculturist spoke on the points raised by him. There was some discussion on the subject of the form, examination and maintenance of indicator plots and lines, in which Messrs. F. C. Osmaston (Bihar and Orissa), M. D. Chaturvedi (United Provinces) and M. V. Laurie (Madras) took part.

The following resolution was proposed by Mr. Mobbs (United Provinces) and seconded by Mr. Allah Baksh (Punjab), and passed by the Conference.

RESOLUTION ON ITEM 6 (*a*).

Resolved that—

1. *This Conference accepts the method of linear enumerations by squares as the standard method of assessing natural regeneration, while still recognising the value of compact indicator plots for the study of individual plants under given conditions.*

2. *The method to be followed and the factors to be evaluated should be as detailed in the Experimental Manual but the percentage stocking should not be reduced to a basis of 1,000 plants per acre ; instead of this, it should be the actual percentage based on the number of stocked and unstocked squares.*

3. *No definite establishment height should be fixed for each species to be applicable to all India, but agreement should be reached between Provinces concerned fixing a standard establishment height for a species in the same type of forest.*

4. *The possible value of a more intensive enumeration of the regeneration at the initiation of an experiment and at periodic intervals in its progress should be kept in mind and carried out wherever feasible.*

PAPER (I).

By E. C. Mobbs, *Silviculturist, United Provinces.*

(Read in opening the debate.)

There are three chief methods of assessing natural regeneration :—

(*i*) The comparatively small indicator plot,

(*ii*) Enumeration of stocked squares,

(*iii*) Selective counting.

Originally in the United Provinces, and probably also in other Provinces, a number of small scattered indicator plots were laid out in all natural regeneration experiments. It was found, however, that these plots, while affording very valuable information about the development of individual seedlings under a variety of conditions and thus fulfilling an extremely valuable function, did not give a proper idea of the progress of natural regeneration over a large area.

This matter was considered at the 1929 Conference, which accordingly recommended as part of the report of the committee on Item 6 the adoption of two other methods. The method of enumeration of stocked squares was recommended as the best when practicable, and the selective counting method to be used when more convenient.

The method of selective counting has perhaps the advantage that it involves the enumeration of slightly more evenly distributed plants than the method of stocked squares. But actual experience in the United Provinces, and also in Punjab, Bengal and Bihar and Orissa, has shown that the method of squares is in practice the more satisfactory, and that it should be carried out in the form of lines run through the regeneration area. The method is very simple and comparatively quick. In the U. P. last cold weather, in addition to a fair amount of special statistical work in the irregular *sal* forests, we had no difficulty in laying out 96 such indicator lines, as we call them, each from 500 to

800 feet long, and we propose to do a similar amount this cold weather. Further, if the lines are made easily determinable, as for instance running from tree to tree, the trees being serially numbered, periodic remeasurements are extremely simple.

I think, therefore, that this conference should now go one step farther than the 1929 Conference, and definitely affirm that the method of enumeration by squares should be adopted as our standard method of assessment of natural regeneration, while still recognising the value of small compact indicator plots for the study of individual plants in given conditions.

There are one or two further points to be considered. Firstly there is the question of the data to be collected and the compilation of these data. I think there can be no doubt that we should all adopt the methods given in the Experimental Manual,—*i.e.*, that we should enumerate and measure E—established seedlings, or in their absence U—unestablished seedlings, and thereby calculate the Established percent, the Unestablished percent, and the Established Stocking Factor, and that we should also record R—recruitment, in those squares without E or U. By making this obligatory, our records would be comparable.

I suggest, however, that there is no need to calculate the percentage stocking on the basis of 1,000 plants per acre, as suggested in the Experimental Manual. The percentage stocking can simply be expressed as the percentage of stocked squares compared with the total. In the case of R we should follow the suggestions of the Manual and assess it at half the spacing adopted for E and U—*i.e.*, there should be 4 seedlings to a square to count as full stocking.

With regard to the Establishment Height, I suggest that it be left to the Provinces to decide what height they wish to adopt for any particular species. Conditions vary so much that what might be considered well established regeneration in one Province might not be so considered in another. To take a case in point,—in the table on page 110 of the Experimental Manual, 6 feet is suggested as a suitable Establishment Height for *sal*, and I imagine that this would be quite suitable for Bengal, Assam and Bihar and Orissa. In the U. P., however, I have tentatively adopted a height of 10 feet as Establishment Height ;—we can and do fairly conveniently measure to this height, and until a seedling has reached that height it cannot be considered really free from competing weeds, deer damage, frosts and other forms of damage. Once it has reached 10 feet, we can be fairly certain that it will go straight ahead. The combination of inimical factors necessitating this Establishment Height is probably peculiar to the U. P., and consequently I think that each Province should be left to decide its own Establishment Height for any species.

It should further be free to Provinces to collect additional information. This of course is always possible in any experimental work, but in this particular case, I think we should definitely draw the attention of the Provinces to the possibility by including reference to it in our resolution. In the *sal* natural regeneration experiments of the U. P., we have many plots in which there are a large number of seedlings, which are mostly very small. Although ultimate assessment of regeneration will be carried out by 6 feet squares in indicator lines, it was thought that since the regeneration was small and we usually get a very large mortality of *sal* seedlings, it was necessary in the first instance to get a more detailed idea of the quantity of regeneration on the ground, at a much closer spacing than 6 feet by 6 feet. Consequently we recorded up to a maximum of 4 E or U plants per square, giving us on the average details of stocking at 3 feet by 3 feet. Also it so happened that there was a large amount of recruitment on the ground in some areas and much less in others. We therefore recorded recruitment in every square and not only in the squares unstocked with E or U plants. We have thus a detailed record of all sorts of seedlings over the whole of each plot in the initial stage of our experiments, and can calculate, in one of the ways mentioned in the note I have written for the conference on this point, to what extent the recruitment is stocking squares without other seedlings and to what extent it is simply augmenting stocking where older seedlings already exist.

To give a concrete example, I may mention two plots in Ramnagar division experiments 6 and 7, two experiments less than 20 miles apart in very similar submontane *sal* forest. In 1933 we had an exceptionally good *sal* seed and seedling year, and the whole forest looked as if it was covered with seedlings. Calculation of the stocking per cent. in the way described in the Experimental Manual gave us for the one plot 70 per cent. for old seedlings *plus* 13 per cent. recruitment, while for the other plot the figures were 27 per cent. for old seedlings *plus* 21 per cent. recruitment. It is difficult to compare the recruitment figures as they stand. On the face of it one might conclude that in the event of the old seedlings dying, the second plot with 21 per cent. recruitment might end up with a better stocking than the first plot with only 13 per cent. recruitment. Actually, however, the first plot was very much better stocked, and enumeration of all squares and not simply the squares without older seedlings showed that it had 77 per cent. recruitment compared with only 34 per cent. in the second plot.

I do not propose to make all subsequent measurements or counts on the same scale—for remeasurements we shall simply adopt the standard system detailed in the Manual. But in dealing with a species such as *sal* where a large percentage of the seedlings, both U and R, disappear, I think an initial detailed analysis of the sort we have made in the U. P. is desirable to give a truer idea of the conditions we started with, and to enable us better to assess comparability of plots. I do not propose that other Provinces should do exactly the same, but I would suggest that while adopting a standard method, we should not necessarily bind ourselves to its limitations, and that Provinces should keep in mind the possibility of more intensive records, either for analysis of initial conditions or at periodic stages in the progress of natural regeneration, or in any special conditions.

Summing up then, I would suggest that the conference adopt some such resolution as the following :—

1. This conference accepts the method of linear enumerations by squares as the standard method of assessing natural regeneration, while still recognising the value of compact indicator plots for the study of individual plants under given conditions.

2. The method to be followed and the factors to be evaluated should be as detailed in the Experimental Manual, but the percentage stocking should not be reduced to a basis of 1,000 plants per acre ; instead it should be the actual percentage based on the number of stocked and unstocked squares.

3. No definite establishment height should be fixed for each species to be applicable to all India, but Provinces should be free to determine the establishment height most applicable to their local conditions*.

4. The possible value of a more intensive enumeration of the regeneration at the initiation of an experiment and at periodic intervals in its progress should be kept in mind and carried out wherever feasible.

Note (i) by the Silviculturist, Bengal.

The following method on the lines indicated in Volume I of the *Experimental Manual* has been used in the Chittagong Hill Tracts division at the suggestion of the Central Silviculturist for estimating the recruitment and growth of seedlings of different miscellaneous species in the experimental plots in the Evergreen Forests.

A diagonal line is made through the plot and about one hundred 6′ square blocks or sections (on one or other or both sides of the diagonal line, the number of blocks naturally varying with the size of the plot), are laid out by a measuring tape and a staff 6′ or 12′ long held at right angles to the tape. The Indicator Plot chart is similarly divided using the big squares of a section paper for each block of 6′ × 6′. The height measurement only of the *biggest plant* of all important species occurring in each block is noted at every enumeration and recorded in the corresponding section of the squared paper. The biggest plants will not be the same every time. Abbreviations are used for vernacular names—such as :—

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*Note.—In the course of the debate Mr. Mobbs altered the 3rd proposal which then read as follows :—

3. No definite establishment height should be fixed for each species to be applicable to all India, but agreement should be reached between Provinces concerned to fix a standard establishment height for a species in the same type of forest.

• • • • • • • •

G. for *gurjan.*
T. for *tali.*
N. for *nageswar.*
K. for *kamdeb.*
C. for *chapalish.*
Ch. for *choungri.*
P. for *pitraj.*
R. for *raktan,* etc.

Any species below 6″ height (biggest plant) in the 6′ × 6′ block should not have its height measurement recorded, but the letter " R " only noted to indicate the presence of recruitment.

It is desirable to have further measurements to compare the height growth of the different species in the plots under the different methods of treatment and so a selected number of plants in each plot were tagged with a number. About 10 plants of each species were selected so as to include roughly 3 height classes, *viz.,* average seedling of the year (lowest height class), established seedling (medium height class) and sapling stage (highest class). These measurements are entered in E. P. Form 6.—*C. K. Homfray.*

Note (ii) by the Forest Research Officer, Bihar and Orissa.

While agreeing in general with the proposed classification of regeneration for *sal* given on page 110 of the *Silvicultural Research, Manual,* Vol. I, I should prefer a little more detail. I should also prefer the unestablished stage to be subdivided into unestablished stages 1 and 2, unestablished stage 1 being from recruitment up to a height of 3′, and stage 2 from heights of 3′—6′. I suggest this because in Bihar and Orissa, when *sal* regeneration reaches a height of 3′ it is often practically established and it is up to this height that it is most delicate. In the Singhbhum forests at least, when once regeneration is over 3′ high (*i e.,* unestablished stage 2) there is nothing to fear, and to obtain full stocking of this stage 2 would generally be a satisfactory result to an experiment.

For assessment of stocking, I prefer the method by enumeration of stocked squares (the squares to be 5′ × 5′ for convenience of plotting).) This method can give both a visual picture on a chart and also a numerical expression. The squares should run through as much of the Experimental Plot as possible, and for this purpose one or more long narrow Indicator Plots 10′ wide running across say half of the Experimental Plot is better than a wider rectangle containing the same number of squares. When 75 per cent. (or other locally accepted percentage) of the squares contain one or more established regeneration, regeneration may be said to be satisfactory.

In addition a photographic record of progress should be maintained whenever possible.—*F. C. Osmaston.*

Note (iii) by the Silviculturist, Forest Research Institute.

METHODS OF ASSESSING PROGRESS OF NATURAL REGENERATION.

The *Experimental Manual* describes two methods of assessing regeneration (page 110), the enumeration of stocked squares and selective counting, the former being preferred by the Silvicultural Conference. Further experience has confirmed the wisdom of this preference, and has shewn that the counted squares should be on lines across the experimental plot, and not in a compact square or rectangular Indicator Plot as envisaged in the Manual. This lines-of-squares method is both simple and quick in the field, and far more satisfactory than the compact indicator plot from the point of view of sampling. It has been applied with success in Punjab, United Provinces, Bengal, Bihar and Orissa, and is worth adopting as our standard method till we light on something better.

The United Provinces has found that the suggested method of recording additional recruitment needs development to differentiate between its contributions towards stocking squares without older seedlings, and towards augmenting the stocking where older seedlings already exist. In practice, the difference proposed is in recording 1, 2, 3 or more U or E plants and 1, 2, 3 or more R plants per 6′ square, in addition to measuring the best U or E on each ; the *Manual* suggests recording R only in the absence of U or E, which presumably the United Provinces finds inadequate.—*H. G. Champion.*

Report of Debate.

Mr. Mobbs : [Address given on pages 65—67.]

Mr. Champion : The method of assessing regeneration was one of the first things to which we gave our attention when the Provincial Silviculturist in the United Provinces took up the question of systematic research into *sal* regeneration problems, and we started off with the 15′ × 15′ quadrat. We mapped and measured everything on it. After we had done this a few times we found that our plots were no longer representative of the area as a whole even if they had been initially so. The change over to the method of stocked squares was the direct outcome of our early experience, and the modifications proposed by Mr. Mobbs now are exactly what we should expect.

I think perhaps when I summarised the situation in the *Experimental Manual,* I rather overstressed the view that we have been counting and measuring too much, and possibly I went to the opposite extreme. The sub-division of the 6 ft. square in the case of recruitment was provided for but it was suggested that one need not bother about recruitment if there is even one large seedling in the unit of count. I quite agree with Mr. Mobbs that counts of recruitment are very useful. Some arbitrary number could be fixed as the maximum to be counted. The count is very easy, but I am still strongly of opinion that we should keep our *measurements* down to the smallest number we can manage with. It is also particularly useful, as Mr. Mobbs has said, to have the initial record as full as possible. Ordinarily one has a clear idea of what is wanted when one starts the experiment, but as time goes on one often wishes one had a little further information about the initial condition. I am very strongly in favour of a full initial description, count, measurement, or whatever it may be, of the plot, so long as it does not lead to a lot of unnecessary work in subsequent records. This is very liable to happen unless it is very clear from the records that it should not be done.

The other point raised by Mr. Mobbs which is an important one for settlement was the question of accepting a standard establishment height. In general terms I would agree with Mr. Mobbs that the height or size adopted must vary with circumstances. I would ask Mr. Mobbs in particular whether in the case of *sal* he would vary his height in one particular province or maintain a single standard under all conditions. Mr. Mobbs said that at present he proposed a single establishment height for *sal* for the whole of the United Provinces. It would be much more satisfactory if we could agree on a common method granting that different conditions will call for different standards.

Mr. Osmaston : Actually in some of our areas in Bihar and Orissa, 3 ft. would be sufficient to be considered established, in other 4 or even 6 ft. whereas Mr. Mobbs has adopted 10 ft.

Mr. Champion : Will it not meet requirements if in the case of *sal* we settle on a standard for each of our types ? We have recognised 13 types ; 2 or 3 standards would possibly cover the whole lot. Where regeneration is easy the standard will be lower and where it is difficult it will be higher.

Mr. Howard : Would it mean two heights for your province ?

Mr. Osmaston : Yes, we would not mind that.

Mr. Champion : We have agreed that any results if obtained one type should not be applied in an other without confirmatory tests.

Mr. Chaturvedi : As an improvement on the 15′ × 15′ quadrat, we laid out plots of 20 ft. × 5 ft. but these too gave us insufficient results, so we laid out about 4 or 5 plots 1|10th of an acre each in the experimental area. These were quite sufficient for our purpose, and served us very well. We had representative seedlings marked with T-shaped nails. We had a form of our own and we gave the height of the seedling year by year and that gave us a very good picture of conditions. Then the difficulty of damage by deer, cattle and people arose, so we put up barbed wire fencing which altered conditions.

Mr. Howard : It really comes down to this that the indicator plots which you had originally, give perfectly good data for individual plants, but when you try to get to something that is representative of the area as a whole, then they do not. That is why the new developments have come.

Mr. Chaturvedi : No, the position was that the indicator plots did indicate the areas as a whole and I still feel that the work is simpler with an indicator plot in which we also study the development of individual seedlings.

Mr. Mobbs : In an indicator plot with a hundred seedlings numbered, there are also usually many seedlings which are not numbered. It was frequently found in such cases that the numbered seedlings, originally the best, did not all develop well, and that unnumbered seedlings developed better, as that from the point of view of establishment of regeneration, we were not measuring the right seedlings. We had the alternative of numbering a fresh or of adopting another method. In the method of squares you choose the best seedling in each square. Whether it is the same as you saw five years ago does not matter. What you want to measure are the plants that are going to be your ultimate crop.

Mr. Chaturvedi : The method of squares gives a false sense of security.

Mr. Champion : We all seem agreed that these numbered seedlings will not remain the best plants on the plots. I think we all expected it from the start and we have merely now to decide which seedlings it is better to observe. The whole idea of counted squares has developed from an appreciation of the fact, but as in a great many of our problems we are still interested in individual seedlings, it is suggested, and is actually being carried out in Bengal, and the Punjab, that we have numbered seedlings in the counted squares. The arrangement at present is that the lines are laid out and the range in type of seedlings examined. The seedlings are then roughly classified on simple lines as any working plan officer or ranger could do, and a few of each type are numbered for keeping under observation.

Mr. Laurie : We have got one or two experimental plots in which we have laid out indicator plots in lines of squares. Formerly we had compact indicator plots which were sub-divided into squares. These are now being supplemented by lines of six ft. squares.

ITEM 6 (*b*)—(*d*).

Soil and Ecological Investigations.

Papers were called for on (*b*), *Soil problems*, (*c*), *Root systems*, and (*d*), *Ecological problems.* On the first subject notes (pages 85, 86) were received from the United Provinces, Bengal, Assam, and Bihar and Orissa, and a note (page 86) was circulated by the Central Silviculturist. The Silviculturist, Burma, submitted a note (page 78) by Mr. CHARLTON, Agricultural Chemist to the Government of Burma, on the growth of *Gmelina* as affected by the composition of the soil. Short notes on root studies were received (page 86), and a paper by Mr. MOHAN (Punjab) and other notes (page 87) on ecological problems.

Mr. GARLAND opened the debate referring to the need of greater knowledge of forest soils and what goes on in them. Dr. PURI and MESSRS. TREVOR, MOHAN and MOBBS took part in the ensuing discussion. At the following session Dr. PURI read an address (*cf. infra*) which Dr. MACKENZIE TAYLOR, Director of Irrigation Research in the Government of the Punjab, had been prevented by illness from delivering personally. Dr. PURI and Mr. HOON demonstrated after the address various methods of pH determination, mainly electrical, in the laboratory, and subsequently explained the features exhibited by soil profiles in the Experimental plantations at the Research Institute, and in *sal* and bamboo forest at Lachiwala, Dehra Dun division.

The following resolution was proposed by Mr. PURKAYASTHA (Assam) and seconded by Mr. GARLAND (Bombay), and adopted by the conference.

RESOLUTION ON ITEM 6 (*b*)—(*d*).

RESOLVED that—

(1) *This conference desires to bring to the notice of Government that the appointment of an Ecologist has been considered so essential at the Forest Research Institute that it has been shown on the cadre of the Institute since 1920, but this post has not yet been filled.*

(2) *This conference believes that work on soils and ecological problems is of the greatest importance in the elucidation of problems connected with the regeneration of forest crops. Such work is essential both in the F. R. I. and the Provinces. The assistance of an expert in this branch of knowledge is urgently required.*

(3) *This conference also urges that Provinces should give facilities whereever possible for their officers to take up work on these subjects.*

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PAPER (I).

Contributed by DR. MACKENZIE TAYLOR, *Director of Irrigation Research, Punjab.* (Read by Dr. Puri of the same department).

Mr. Trevor asked me to deliver an address to the Conference of Forest Officers on Soil Research methods. My main experience of soils has been connected with agriculture and on two occasions I have been introduced to forest soils through Mr. Trevor. My knowledge of the forest soils in India is limited and my interpretation of the results of analyses is consequently open to correction. I am aware that the results which I put forward may not be generally applicable and will need modification to suit particular conditions. I will attempt to deal mainly with the general aspects of the problem and will indicate the application of the results in particular cases.

It is difficult to know where to start so I will give a brief resume of the subject commencing with soil genetics.

Item 6 (b)—(d).]

1. *Soil Formation Process.*—The important materials forming rocks and having a bearing on the formation of soils can be grouped under four heads—

(*a*) Bases such as soda, potash, lime and magnesia.

(*b*) Sesqui-oxides of iron and aluminium.

(*c*) Silica, and

(*d*) Organic matter.

In all soil forming processes the removal of bases from the original rock takes place.

The soil forming processes fall into two groups—

(*a*) Anaerobic.

(*b*) Aerobic.

Under anaerobic conditions peats are formed though peat can also be formed under aerobic conditions when some other factors such as lack of moisture limit bacterial activities. Under anaerobic conditions Gley soils are also formed. The characteristic of a Gley soil is the removal of iron oxide from certain layers of the soil which become blue in colour and the redecomposition of the iron oxide in bands forming, in extreme cases, what is called an ' iron pan '.

Under aerobic conditions the decomposition processes which take place fall into four main groups—

(*a*) Hot arid conditions,

(*b*) Moist tropical conditions,

(*c*) Cool humid conditions, and

(*d*) Cold arid conditions.

(*a*). Under extreme hot arid conditions no alteration in the composition of the rock material takes place and only a sand consisting of unchanged rock particles is formed. Under slightly moist conditions the tendency is for the rock to be decomposed and the bases to accumulate. This decomposition may give rise to three types of soil—

(1) Solonetz soils characterised by the presence of alkali carbonates, (alkali soils).

(2) Solonschak soils characterised by the presence of neutral salts, (saline soils).

(3) The soils characterised by the presence of alkaline earth carbonates such as the surface limestones of South Africa (calcareous soils).

Under semi-arid conditions which at some period of the year admit of considerable growth of plants but do not admit a rapid decay of the organic matter during the succeeding drought, black earths or Tschernosem soils are formed (black cotton soil). Under slightly more arid conditions than the previous where plant growth is little, chestnut coloured earths are formed. These are deficient in organic matter.

(*b*). Under moist tropical conditions the characteristic is the rapid chemical decomposition of mineral matter in the original rock. Under these conditions the bases are leached leaving an acid residue. This acid residue tends to break down into its constituent oxides, silica and the oxides of iron and aluminium, the silica being removed by the alkaline solution formed by the bases. The residue in this case is a laterite. Various degrees of laterisation can be noted in the field according to the stage which the process has reached.

(*c*). Under cool humid conditions the bases in the rock are leached, organic matter is partially decomposed and the products of this decomposition lead to the leaching of the sesqui-oxides of iron and aluminium. These sesqui-oxides may be distributed throughout the weathering material giving rise to the 'Brown Earth' or they may be deposited at a lower level leaving a bleached layer above giving rise to Podsols.

(*d*). Under cold arid conditions the breakdown of the rock is again physical in character and, what is called a "Skeletal" soil is formed.

2. *Classification of Soils.*—Soils may be classified into two main groups—

(*a*) Immature soils in which the soil formation processes have not had full play and therefore the influence of the parent rocks is still apparent. The presence of calcium carbonate invariably indicates this type.

(*b*) Mature soils in which the process of formation has had full play and the parent material is exerting a minimum influence.

Immature soils can be sub-divided into two types—

(1) Rendzinas, or humus carbonate soils.

(2) Skeletal soils—largely the product of physical weathering.

Mature soils can be divided into the following groups according to their modes of formation—

(1) Laterites.

(2) Tschernosems.

(3) Chestnut soils.

(4) Podsols.

(5) Peats.

(6) Saline and alkaline soils.

Dealing very briefly with some of the soils in the Kulu Valley as an illustration, the examination has shown that the nearest class to which they belong are podsols. They are, however, not typical podsol soils and probably should be classed as immature podsols. This is due to the difference between the climatic conditions in the Kulu Valley and the cool humid conditions responsible for production of mature podsols.

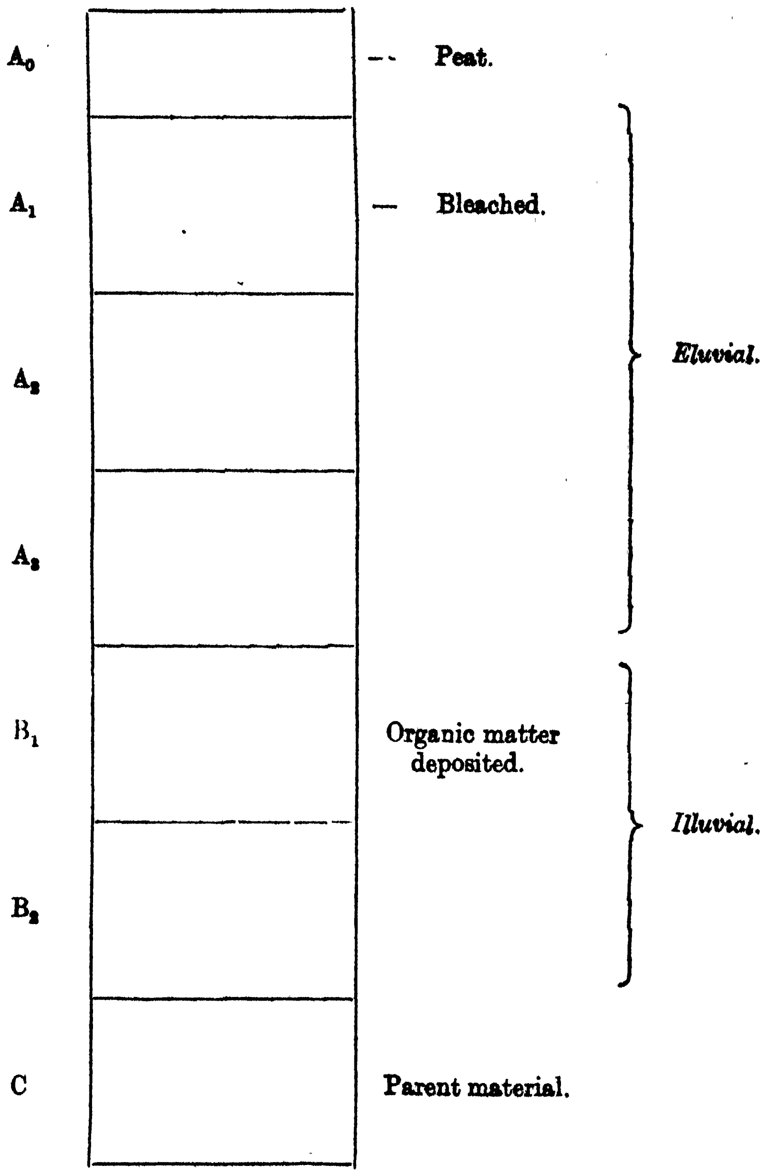
In the Kulu Valley the climate is characterised by the following.—

A cold dry period followed by a cool moist period due to the melting of snow. This in turn is following by a dry warm period to be followed in turn by a cool humid period. While the general tendency in this case is for cool humid conditions, the dry periods tend to hold up the podsolisation process and hence immature podsols result.

In the plains of the Punjab, there are well marked cases of the development of both the Solonschak and Solonetz soils, the characteristic formations under arid conditions. From the forestry point of view, they need a different type of examiation from that of the hill soils.

3. *Soil Profile.*—Until recent years it has been customary to study soils mainly from the point of view of the surface soil and the sub-soil. It is now regarded as essential, in defining soil characteristics, to study the soil profile. The soil profile may be defined as a vertical section of the soil from the surface to the parent rock which has not yet undergone decomposition. From what has been said of the soil forming processes, it will be seen that this section may be divided into a series of layers or zones from which the constituents have either been leached or in which they have been deposited. These zones may be sub-divided into horizons each having special characteristics within the zone. For convenience in classification the zone from which materials have been leached is called the "Eluvial" zone, and the sub-divisions of this zone are labelled the A horizons. The zone in which the leached materials have accumulated is called the 'Illuvial' zone and the sub-divisions of this are called the B horizons. The C zone is the parent material. In the Kulu Valley as

has been pointed out the most important profile is the podsol type. This may be taken as an illustration to show the sub-divisions of the various zones in the profile. A complete podsol profile is as follows :—



Description of a mature podsol is as follows.—

A typical podsol profile consists essentially of three horizons, A or eluviated horizon, B the horizon of illuviation enriched by certain of the constituents leached from the A horizon, and C the parent material. A detailed description of the various horizons with their morphological and chemical characteristics is given below :—

Description of Horizons.

A_0—Decayed humus accumulative layer consisting of leaf mould and forest litter. It is the starting point of many reactions leading to mineralisation. One of the distinctive chemical properties is its ***high base exchange capacity,*** another distinctive chemical property of A_0 in podsols is its ***high unsaturation as regards bases.***

A_1—Light grey with a straw-coloured tinge impregnated with some humus material and of a powder loose silty texture with a sandy appearance. *This structureless condition is one of the distinctive characteristics of this horizon.* It has a lower base exchange capacity than A_0, low bases and sesqui-oxides contents, enrichment in SiO_2 and comparatively high unsaturation. A great drop takes place in the base exchange capacity from A_0 to A_1. SiO_2 is higher in A_1 than in any other horizon except A_2. Sesqui-oxides are lower than parent material.

A_2—is a component part of the horizon of eluviation. It differs from A_1 in being thoroughly podsolised. The colour is bleached ash-grey to whitish grey. *This bleached ash-grey colour is the most characteristic morphological feature of this horizon and is very well developed in a characteristic podsol profile.* Base exchange capacity lower than A_1, more unsaturated, usually lower in calcium and sesqui-oxides and higher in SiO_2. The unsaturation of A_2 furnishes chemical evidence of the podsolised state of the soil. The pH of A_2 is lower than other horizons.

B—Its accumulative character is very distinctive feature. It is a horizon of illuviation. B_1 dull brownish colour with some light and some dark streaks. This horizon is compact and heavy. B_2 light brown colour. Chemically the B horizon has lower SiO_1, higher sesqui-oxide, increase in bases and in base exchange capacity, lower unsaturation. B_1 has a higher organic matter content than A_2.

C—the parent material.

Other profiles may be dealt with in a similar manner to that which has been illustrated by the podsol profile. The zones and the horizons are demarcated and measured in the field, the samples of which are obtained for examination in the laboratory.

4. *The Active Constituents of the Soil Profile.*—The active constituents of the soil profile are the clay and the organic matter. In many respects the behaviour of these two constituents is similar. As an example one may take the behaviour of the clay and the organic matter towards neutral salts. Both the clay and the organic matter to some extent behave like weak acids and when brought in contact with solutions of neutral salts base exchange can take place as illustrated in the following equation.—

H_2-Clay + 2NaCl = Na_2-Clay + 2HCl.

It will be seen from this equation that when sodium chloride reacts with an acid soil a sodium clay is formed and hydrochloric acid liberated. The hydrochloric acid can be easily leached from the soil so that the final residue is a sodium clay. This sodium clay is unstable in the presence of water and undergoes hydrolysis according to the following equation.—

Na_2-Clay + 2HOH = 2Na OH + H_2-Clay.

The formation of the sodium hydroxide according to the above equation accounts for the alkaline reaction of soils in which sodium is present as a base. Soils of this type are extremely difficult to deal with owing to the presence of alkali sodium hydroxide which causes deflocculation of the clay and consequent impermeability of the soil which gives rise in turn to anaerobic conditions. The action of lime in neutralising soil acidity is based on a similar reaction to that illustrated with sodium chloride. The bases entering the clay and the organic matter in this manner are known as replaceable bases and exert a considerable influence on the reactions of the horizons in which they are present. For instance in a podsol, since the bases are leached from the A horizons these will tend to become acid. As the bases are redeposited in the B horizons, the B horizons will tend to become more neutral in reaction.

5. Having obtained samples of the various horizons certain examinations are made in the laboratory by which they may be characterised in order to trace the reactions involved in their formation. The most important determinations are.—

(*a*) pH value.

(*b*) The quantity of exchangeable bases present and the base exchange capacity.

(*c*) The ratio of silica to sesqui-oxides in the clay fraction, and

(*d*) The determination of organic matter.

(*a*). The pH value for simplicity may be defined as a scale of acidity and alkalinity in which pH 7.0 is neutral, pH 0—7.0 is acid and pH 7.0 to 14.0 is alkaline. Two methods for the determination of pH value will be demonstrated by Dr. Puri and Mr. Hoon. Both of these methods are in use in my laboratory, that of Dr. Puri being specially applicable to work in the field.

Item 6 (b)—(d).]

(*b*). The base exchange capacity of a soil may be defined as the quantity of a base required to saturate the soil. If the exchangeable bases actually present are determined and the base exchange capacity is also found, the ratio between these two quantities gives what is known as the "Degree of saturation". This is an important factor in diagnosing soil type. If the degree of saturation is high the soil is probably neutral or slightly alkaline in reaction and it indicates that little leaching has taken place. If the degree of saturation is low, then leaching has been considerable and the soils undoubtedly have an acid reaction.

(*c*). Recently a great deal of importance has been attached to the ratio of the silica to the sesqui-oxides in the clay fraction of the various horizons. As has been pointed out in the case of the podsol profiles the sesqui-oxides tend to be removed from the A horizons and deposited in the B. In this case the silica to the sesqui-oxide ratio in the A horizon will be much higher than that in the B. This ratio therefore forms a valuable indication of the soil type being dealt with.

(*d*). The determination of organic matter is important as again it may characterise soil types. In the podsol group again for instance there is a tendency for decomposition products of the organic matter in the surface layers to accumulate in the B horizons.

The determinations detailed above are tedious and need considerable skill. They are, however, now forming the main methods for the routine examination of the soil profiles.

6. *The information acquired in the field in taking Soil Profiles.*—The information taken in the field is illustrated by the form attached (p. 78).

7. *An exhibition of the Soil Profiles.*—Some profiles from Kulu Valley illustrate the different types that may be obtained in a relatively small area. Profile 60, 63, 40 and 49 illustrate what I have classified as Podsol type in Kulu. It will be seen that these four profiles are relatively complicated. They are, however, not typical podsol profiles. One striking difference between these profiles and typical podsols is the high content of replaceable calcium in the A_0 horizon. This must be due, in the first instance, to the high calcium content of the needles of *chir*, blue pine, and deodar found growing on these four sites. Secondly it must be due to the difference between the climate in Kulu and the typical podsol forming climate which has been described previously. This high content of calcium in the A_0 horizon exerts a considerable influence on the base content of the various horizons throughout the profile. The acidity of the A horizons does not develop to the extent that would be expected in a podsol. As a consequence though the accumulation of the sesqui-oxide in the B horizon is marked, it is not so marked as it should be, were the podsol profile fully developed. The profile, however, illustrates the variation in colours in the horizon that are to be looked for. The B horizon of profile No. 60 is of particular interest as the precipitation of the sesqui-oxide of iron in this region is very marked. In the actual profile it was so marked that the iron oxide had recemented sand particles together to form a material of the nature of sand-stone though not sufficiently compact to prevent the entrance of the roots. In taking these profiles it was noted that the majority of the fibrous roots were confined to the A horizons, the larger roots occupying the B, but none of them entering the C zone. Profile Nos. 60 and 63 were derived from quartzite. Profile No. 40 was derived from mica schist. It will be seen that although the parent materials from which the profile has been derived are dissimilar the profiles themselves exhibit common characteristics. Profile No. 55 represents an approach to the Brown Earth type. As was pointed out earlier the characteristic of this profile is an absence of the A_0 horizon and the distribution of the sesqui-oxide throughout the A and B horizons. The difference between A_1 and B horizons in the damp condition was more marked than appears in the profile as exhibited. Profile 56 will be referred to again later and is of particular interest. The profile contains calcium carbonate and hence has to be classified as 'Immature'. The material is probably of glacial origin, and on account of the organic matter present it has been classified as the "Rendzina".

Profile No. 51 is exceptional and is given here as an illustration as to how easily one may be led astray in this type of work. It will be noticed that it has an A_0 horizon and underneath this an A_1 which is apparently a bleached layer. In the field this was classified as a typical podsol. In the laboratory it was shown not to belong to the podsol type since the A_1 was found to contain considerable quantity of calcium carbonate which should not have been present had it been podsol. This specimen was obtained at Nagni and the area was under spruce. It may be an accidental occurrence but without further examination I am at a loss to account for the presence of calcium carbonate in the A_1 horizon of the complicated profile of this nature.

8. *Characteristics of some of the Soil Profiles in Kulu with reference to Forest Type.*—Soil profiles of four types of forest were examined in Kulu. These were spruce, deodar, *kail* and *chir*. From the results of examination it seems that spruce is capable of withstanding the greatest extremes of acidity and alkalinity. Deodar and *kail* appear to favour those types of soil with a pH value of about 6.0 while *chir* appears to prefer a soil with a pH value of 6.0 and neutral. Profile No. 56 is of particular interest with regard to deodar. The deodar on this area was natural and was pointed out to be extremely poor. The characteristic of this soil was its high content of calcium carbonate. It is probable therefore that any soil containing calcium carbonate would be unsuitable for a deodar plantation. In contrast with this is Profile No. 51 which has an A_1 horizon rich in calcium carbonate. On this area spruce was excellent though there was no regeneration. From this it would appear that if a soil contains calcium carbonate, spruce might be a better crop to attempt than deodar. Stating the above in terms of soil type it seems that deodar and *kail* can stand a higher degree of podsolisation than *chir* while spruce is less selective.

Another method of defining soil types is according to their physical composition. Some interesting information has been obtained on this point. Under natural forests the heaviest type of soil was found to be occupied by deodar. *Kail* also required a heavy type of soil but there was an important distinction between this soil and that carrying deodar. Deodar appears to require in addition to a heavy type of soil a deep soil. *Kail,* while requiring a heavy soil, can at the same time flourish when this soil is thin. This difference between natural deodar and *kail* soils was most marked. In no case under deodar were stones found to be present in the A and B zones. Under *kail* boulders were invariably found to be present in both the A and the B zones. This leads to the conclusion that deodar requires moister soil conditions than *kail.* Such appears to be the case from aspect and other factors.

Chir seems to grow on the lighter soils, the sand fraction being the characteristic portion of the soil in a profile carrying *chir.* It would appear that *chir* can flourish in situations drier than *kail.*

Spruce again seems to be less selective as it is found on a much wider range of soil types as regards physical composition. It was found to be growing on a soil profile containing 80 per cent. of sand and also on one containing 30 per cent. of silt.

9. I have been asked to illustrate the practical application of soil examination with reference to the growth of plants. During the investigations in Kulu one or two instances came to light.

(*a*). *Transplantation of Deodar at Jarri.*—An area near Jarri on which transplanting of deodar had failed was examined. The characteristic of the area was that it was adjacent to the river and that a semi-perennial spring existed above the transplanted area. This spring led to periodical waterlogged conditions in the area under transplantation. An examination of the soil profile in this area showed that it was very definitely of the gley type indicating, in the first instance, anaerobic soil conditions and secondly a tendency for impeded drainage by the formation of an iron pan. Had the soil profile been taken before transplanting commenced it would probably have been decided that such an area was unsuitable for a deodar plantation.

(*b*). *Burnt Area at Nagni.*—Efforts had been made to transplant deodar to a portion of the burnt area at Nagni. This area had originally been under *kail.* The examination of the soil profile showed that the soil was very shallow and the profile very simple. It did not in any way represent the other profiles that had been obtained from good deodar areas. It rather represented the shallow conditions that would be more suitable for *kail.* Natural regeneration of *kail* was taking place in this area. Had this profile been examined it would have been found that the soil differed considerably from that carrying natural deodar.

(*c*). *Kagni.*—Attempts had been made to transplant spruce at Kagni. An examination of the profile has shown that although the water-table was moving it was very near the surface and a gley profile had developed. Such a profile appears to be unsuitable for the growth of any of the trees which were investigated.

(*d*). *Borsu.*—At Borsu there was a sharp line drawn between a natural deodar and a natural *kail.* Investigation showed that where the deodar was growing well, the soil was deep and the profile that typical of deodar. Where the *kail* was growing it was found that large boulders were present both in the A and B horizons indicating that it belonged to the *kail* type of profile. While no attempt had been made to transplant in the area this appears to be an instance where the soil conditions have definitely determined the type of crop.

(*e*). *Khanewal.*—At the request of the Chief Conservator of Forests, Punjab, an examination was made of the *shisham* plantation at Khanewal which exhibited different degrees of fertility in various areas. From an examination of the soil profile it was shown that as the pH value of the soil increased, the growth of the shisham became poorer. This investigation enabled standards to be fixed as regards pH value above which transplanting of *shisham* was unlikely to be successful.

FIELD FORM.

Soil of Profile No. 40, dated 3rd June 1934.

Borsu 1|31 C|1.

1. *Geographic position of area.*

2. *Topography, geological and climatic features.*—Good regeneration of deodar under deodar. Profile dry

Aspect—North west.

Slope—Moderate.

Height—7,900 ft.

12-30 P.M. $\left\{\begin{array}{l}\text{wet bulb}\\ \text{dry bulb}\end{array}\right\}$ 45.0°F. / 63.0°F.

3. *Vegetation.*—Sparse ground vegetation, litter of deodar needles.

4. *Description of Soil Profile.*—

A_0.— 0—6 cm. — Peat layer.

A_1.— 6—16 cm. — Sooty black layer, compact.

A_2.— 16—42 cm. — A light sandy coloured layer, compact, contains some small stones. Most of the big roots are in A_1 and A_2 and B_2.

B_1.— 42—50 cm. — Brownish black layer, not so compact, more friable than A_1, A_2.

B_2.— 50—73 cm. — Light brown, compact.

C.— Below 73·0 cm. A yellow with a reddish tinge. layer. Very compact. Mica schist. It is not stained with iron oxide.

* * * * * * * *

PAPER (II).

Contributed by MR. J. CHARLTON, *Agricultural Chemist, Mandalay.*—(Communicated by Silviculturist, Burma).

The Growth of Yemane (Gmelina arborea) as affected by the composition of the soil.

The attention of the Agricultural Chemist, Burma, was first called to this question by the Principal Forest Officer, Federated Shan States, in his

demi-official letter 1118|M.-23, dated 11th April 1930. In this letter Nixon points out that about 350 acres of *Yemane* are planted annually and handed over after about 25 years to the Burma Corporation. Nixon stated that growth seemed to be affected by texture of the soil, stiffness of texture having a bad effect on growth after a time. It was arranged that preliminary samples for examination should be sent to my laboratory, these taking the form of soil monoliths to a depth of four feet from good, bad and medium portions of two compartments. Three such profiles were taken from 1924 plantations in Compartment 11 and three from 1926 plantations in Compartment 20, Panghai Reserve. Mechanical analysis showed no appreciable effect of texture of the soil on growth, all the samples being very similar stiff loams or clay, but great differences in the lime requirement of the soils were found and although only six monoliths were examined, it was considered that this formed a promising line of enquiry for subsequent work. It does not follow, of course, that the growth of *Yemane* is directly affected by the lime requirement of a soil. It might equally well be that the real effect is one of relative ease or difficulty in obtaining calcium and of course the lime requirement of a soil may be expected to be correlated with this.

Preliminary work on the six profiles referred to was finished about the end of 1930 and this note is a summary of subsequent work done since then but excludes from consideration compartments in which the trees have not been measured. It is therefore limited to compartments 11 and 12 for which detailed results are available.

The method of taking samples was to select a number of sites within Compartments 11 and 12, actually 26 in the former and 20 in the latter and to take a soil monolith to a depth of four feet at each of these sites. Subsequently the nearest twenty trees to each soil pit were measured and averaged and taken as representative of the growth particular to that soil pit. The problem thereupon resolved itself in to examining correlations between the growth of *Yemane* and the results of the various chemical and physical analyses carried out.

It will be convenient to recapitulate the chemical and physical determinations carried out. These were necessarily very limited in number and comprised the following :—

(1) pH in water (Colorometric).

(2) pH in KCl (Colorometric).

(3) Lime requirements per cent. Hardy and Lewis—Journal of Agricultural Science XIX (1929), 17.

(4) Sticky point moisture—Keen and Coutts—Journal of Agricultural Science XVIII (1928) 740. A round figure of 16 per cent. was deducted from the values obtained since at the sticky point approximately 16 per cent. water occupies pore space and is not associated with colloidal material. The values so obtained were considered as proportional to the amount of clay in the soils and hence to the texture.

On receipt the monoliths were allowed to dry out and were then sampled by horizons as far as this was possible. Subsequently it was found that owing to the method of planting *Yemane* after *taungya*, considerable changes in lime requirement were to be expected after the burn off and hence further samples were taken after *taungya* by means of a soil auger at depths 0—1′ near the original sampling pits. Fresh determinations of lime requirements and sticky point moisture were made and it was found that the effect of the burning off was to considerably reduce lime requirements in the surface soil. The new values were in turn correlated with the heights of trees.

Results.—For the sake of convenience, results of chemical and physical determinations, together with the heights and girths of trees to which they correspond are attached herewith in Appendix I. In addition to the correlations reported herewith, it is possible to work out many more, *e.g.*, rate of increase or decrease of lime requirement from the surface downwards, $\frac{\text{Sticky point—16 per cent.}}{\text{Lime requirement}}$ for any given depth of sample, etc. Since to work out correlations is very laborious, the method used was to first plot dot diagrams and only to proceed to work out correlations when there was a reasonable prospect of a definite correlation. The list of correlations given is therefore not by any means complete but is considered adequate. The fact that girths as well as heights are given only in the case of Compartment 11 may be noted. Girths were reported only to the nearest inch and hence only a few selected correlations were worked out on girths and these were only done to check the values obtained for heights. Actually the values check as well as could be expected but it would be preferable in case girths are used in future to carry the measurements to the nearest $\frac{1}{10}$ inch and not to be nearest inch.

It should be pointed out that the small correction for grouping (Sheppard's correction) has been left out of account as it is very small and may be ignored at this juncture, more especially as the test of significance without Sheppard's correction is more stringent.

Consideration may now be given to the correlations given in Appendix II, Part I. In this list the correlations have been worked out independently for compartments 11 and 12. From these it appears that :—

1. Although the lime requirement of the surface soil (original) does not give a significant correlation with the heights of trees in 1932, it increases in 1933 with odds of more than 10 to 1 in compartment 12. The fact that *taungya* destroys the correlation between the height of trees and lime requirement in surface soil for both 1932 and 1933 in both compartments may be noted. The fact that the mean whole profile is not so important as regards lime requirement of the surface soil in the first two years of growth is as one would expect.

2. The pH in N.KCl gives an apparently curious behaviour with heights of trees. The surface soil (original) gives a positive but not yet (in 1933) significant correlation while the lowest samples give a negative correlation which is only significant in compartment 12 in 1933. It is therefore only to be expected that the change in pH in N.KCl with increased depth gives a negative correlation which is either significant or on the verge of significance. This is checked by the fact that the difference between the correlations for N.KCl. pH surface soils and lowest horizons is significant in Compartment 12 in 1933 and on the verge of significance for the three corresponding correlations. The tallest trees are associated with soil which increases in acidity with increased depth, *e.g.*, pH 5.0 at the surface and pH 4.0 at 4′ depth. If on the contrary the pH should be 5.0 at the surface and 6.0 at 4′ depth, such soils are a poor medium for *Yemane*. A similar phenomenon has been noted previously in Kenya and also in the Northern Shan States in connection with the growth of coffee, but in the case of coffee increasing acidity from the surface downwards has been found unfavourable for good growth.

3. The sticky point moisture figures are incomplete in the case of Compartment 11, those for original soil not being traceable. Such indications as there are, however, indicate that although the growth of *Yemane* is favoured by lightness of texture in the first year, it is of little importance subsequently. This is not unexpected as the soils are rather heavy in texture on the whole and probably by the second year the feeding roots are beyond the range of soil affected by *taungya*. The difference in the correlations between height of trees and Sticky point—16 per cent. surface soil in Compartment 12 before and after burning, although considerable, is not significant.

The levels of significance for the correlation co-efficient are shown separately for each compartment in Appendix II, Part I as the number of samples differs in each.

Compartment 11 (pits 7—34) was planted up in June 1931 while Compartment 12 (pits 1—20) was planted up in June 1932. The method of planting up was not necessarily identical but there is no very great objection to combining the correlations for two years' growth in each case. Since in the case of Compartment 11 measurements were first taken in 1932, *i.e.*, after two seasons' growth, it is not possible to combine results except on the basis :—

	Height of trees in	Height of trees in	
Compartment 11	1932	1933	etc.
Compartment 12	1933	1934	

Significant results only are quoted in Appendix II, Part II. The value of P is stated in each case and the results of the first two years' growth may be briefly stated as follows :—

(1) The growth of *Yemane* is adversely affected by a high lime requirement in the surface soil prior to *taungya*. Odds between 20 to 1 and 50 to 1 (Odds taken from P|z tables).

(2) High acidity as measured by pH in N.KCl at a depth of 3′—4′ is favourable to the growth of *Yemane*. Odds between 20 to 1 and 50 to 1.

(3) *Yemane* grows better on soils which increase in acidity as measured by pH in N.KCl from the surface downwards. Odds > 100 to 1.

It is likely that the question of pH in N.KCl is correlated with geological formation to some extent. It is in any case a much more reliable determination than the pH in water which is often influenced by the presence of carbon dioxide. For this reason, although the pH in water was recorded for interest, no attempt has been made to correlate this value with the growth of trees.

Summary.—The growth of *Yemane* after two seasons' growth has been found to be negatively correlated with the lime requirement of the surface soil, with the pH in N.KCl of the samples from a depth of about 3′—4′ and with the change of pH in KCl from the surface downwards. All these determinations refer to the soil prior to *taungya*. The correlations obtained suggest that higher values may be obtained in subsequent measurements of heights as time goes on and it is strongly recommended that height or girth measurements but preferably the former should be taken for some years. Since most of the correlations quoted have a minimum odds of 20 to 1, a fair degree of likelihood attaches to the results, this in spite of the fact that comparatively few sampling pits were used.

The main criticism of the results probably lies in the method of sampling whereby one soil pit is compared with 20 adjacent tree heights. It would probably have been better to have taken five or six borings with an auger at arbitrary depths, averaged these and compared them with the mean height of each lot of 20 trees. None the less the general similarity of the results obtained in the two compartments 11 and 12 suggests that the method employed was satisfactory. The two compartments 11 and 12 also appear to be typical of the area where *Yemane* is planted, at least as regards their chemical and physical nature so that it is anticipated that the results will be of fairly wide applicability.

The Profile of Soils in Compartment 12.

In the report given with my letter No. 38|1-A-11, dated the 13th January 1932 to the Principal Forest Officer, Taunggyi the profiles of 70 Northern Shan States *Yemane* soils were briefly described in the Remarks column attached to the report. Samples 1—20 correspond to Compartment 12. Unfortunately the profiles in Compartment 11 (Pits 7—34) are not available.

In the case of Compartment 12, the available information is summarised below :—

——	Pit Nos.	Mean height of trees at end of 1933.
1. Typical Maymyo Red—no horizon changes ..	1, 2, 6 ..	12·22′.
2. Maymyo Red Type—heavy clay variety	7, 11, 12, 13	12·15′.
3. Red-brown soils.	3, 10, 17 ..	11·47′.
	(Note. No. 17 poor growth).	
4. Lateritic appearance (Red)	4, 5, 8 ..	12·20′.
5. Lateritic appearance (Yellow)	9, 14, 16, 19	7·88′.
6. Black alluvium	15 ..	7·25′.
7. Soil with yellow sub-soil and sesquioxides	18 ..	6·92′.

There is therefore some evidence that the best soils for *Yemane* are the red or red-brown soils, more especially those without obvious horizon changes. The black alluvium is probably hill wash. A yellow soil with obvious horizon changes such as represented by pits Nos. 9, 14, 16, 19, 20 and 18 seems definitely poor soil for *Yemane*. Generally speaking, it may be concluded that the deep soils without obvious horizons are immature soils whereas the presence of well marked horizons at less than 4′ depth indicates soils in which the ordinary processes of weathering, etc., have advanced to a further stage and in this sense are older although not necessarily older in the geological sense.

If these facts can be substantiated, it should be possible to pick out by appearance alone the soils best suited to *Yemane*. The best should be either red or reddish brown and should be free from definite horizon changes to a depth of 4 feet. It appears that the yellow soils so common in the Shan States, especially if these have clearly marked horizons, (often accompanied by small granules the size of small shot) are bad soils for growth or *Yemane*. I doubt if black alluvium is common. It is unlikely that it can exist except under special conditions in the valleys where hill wash accumulates and where the supply of water is greater than on the hillsides or on slopes. In any case there is only one such sample in Compartment 12 so that it is unwise to venture an opinion at this stage.

PANGHAI RESERVE COMPARTMENT 12.

APPENDIX I.

Table I.

L. R. = Lime requirement.

S. P. = Sticky point.

Pit No. 1	Heights of trees 1932 (feet). 2	Heights of trees 1933 (feet). 3	Lime requirement % surface horizon (original). 4	Lime requirement % whole profile average (original). 5	Lime requirement % 0—1ft. after taungya. 6	Lime requirement increase or decrease downwards (original). 7	pH in N.KCl surface horizon (original). 8	pH in N.KCl lowest horizon (original). 9	pH in N.KCl difference going downwards (original). 10	Sticky point moisture —16% surface horizon (original). 11	Sticky point moisture —16% mean whole profile (original). 12	Sticky point moisture —16% increase or decrease downwards (original). 13	Sticky point —16% *surface* Sticky point-16% lowest horizons (original). 14	*S. P.*—16% L. R. (whole profile) (original). 15	*S. P.*—16% L. R. (0—1′ only) (After taungya). 16
1	6·92	12·17	·137	·166	·095	—·127	4·8	4·3	—·5	19·97	19·15	1·85	1·09	115·4	158·3
2	7·08	14·67	·322	·439	·129	—·225	4·4	4·1	—·3	24·65	32·22	15·20	1·62	73·4	130·1
3	6·92	14·92	·297	·358	·181	—·156	4·5	4·15	—·35	24·30	28·00	8·70	1·36	78·2	101·1
4	6·75	12·17	·358	·484	·095	—·197	4·5	4·1	—·4	28·95	36·96	15·04	1·52	76·3	267·7
5	6·50	13·75	*Nil*	·170	·042	—·429	7·2	4·3	—2·9	28·54	31·88	9·38	1·33	187·5	717·6
6	4·58	9·83	·205	·267	·030	—·082	4·7	4·3	—·4	20·37	23·29	5·58	1·27	87·3	810·7
7	4·75	13·00	·329	·489	·179	—·290	4·3	4·3	0	33·36	33·11	5·13	1·15	67·7	158·2
8	5·75	10·67	·102	·388	·056	—·471	5·2	4·0	—1·2	28·56	35·15	13·79	1·48	90·6	517·1
9	6·42	12·42	·250	·282	·040	+·044	4·9	4·5	—·4	30·91	32·58	1·76	1·06	115·5	715·0
10	6·00	12·67	·180	·336	·073	—·307	5·0	4·2	—·8	30·13	33·59	10·27	1·34	100·0	293·7
11	6·17	12·50	·199	·298	·088	—·235	4·8	4·25	—·55	25·61	28·66	9·70	1·38	96·2	285·8
12	5·25	10·33	·231	·447	·066	—·398	4·7	4·2	—·5	26·15	33·54	14·36	1·55	75·0	430·8
13	7·00	12·75	·060	·235	·025	—·347	5·1	4·2	—·9	21·37	26·63	10·00	1·47	114·2	871·2
14	5·25	7·83	·223	·185	·118	+·140	4·9	5·5	+·6	21·95	24·54	5·54	1·25	132·6	158·9
15	6·17	7·25	·249	·285	·103	+·006	4·7	5·3	+·6	27·80	29·81	4·95	1·18	104·6	247·8
16	4·50	6·58	·324	·478	·091	—·210	4·5	4·4	—·1	28·65	33·04	9·49	1·33	69·1	282·4
17	6·83	9·92	·435	·628	·090	+·184	4·6	4·1	—·5	24·08	30·39	11·37	1·47	48·4	213·3
18	6·00	6·92	·202	·256	·025	—·194	4·9	6·25	+1·35	23·33	29·53	12·37	1·53	115·4	906·4
19	5·25	6·92	·336	·359	·129	—·059	4·5	4·15	—·35	25·12	33·19	12·96	1·52	92·5	179·0
20	5·17	5·67	·534	·554	·128	+·036	4·15	4·2	+·05	25·55	33·02	12·38	1·48	59·6	198·0
Means ..	5·96	10·65	·249	·355	·089	—·166	4·82	4·44	—·38	25·97	30·42	9·49	1·37	94·98	382·2

PANGHAI RESERVE COMPARTMENT 11.

APPENDIX I.

Table II.

Pit No. 1	Heights of trees 1932 (feet). 2	Heights of trees 1933 (feet). 3	Girth of trees 1932 (inches). 4	Girth of trees 1933 (inches). 5	Lime requirement % surface horizon (original). 6	Lime requirement % whole profile average 0–4′ (original). 7	Lime requirement % 0—1ft. after taungys. 8	Lime requirement increase or decrease downwards (original). 9	pH in N.KCl surface horizon (original). 10	pH in N.KCl lowest horizon (original). 11	pH in N.KCl difference going downwards (original). 12	Sticky point moisture —16 % after taungys. 13
.. ..	13	17·83	5	6	·072	·086	·071	—·028	5·35	5·1	—·25	30·78
.. ..	14	20·67	6	7	·085	·094	·050	—·017	5·15	4·9	—·25	24·57
.. ..	13	18·42	5	6	·243	·318	·147	—·149	4·2	4·2	0	26·42
.. ..	10	15·00	4	5	·324	·347	·181	+·040	3·9	3·9	0	24·44
.. ..	17	24·00	7	13	·072	·092	·054	—·040	5·6	4·2	—1·4	15·56
.. ..	15	22·25	6	12	·230	·279	·157	—·098	4·05	4·8	—·05	25·78
.. ..	12	16·00	5	6	·160	·305	·141	—·224	4·5	4·05	—·45	27·76
.. ..	11	16·50	4	7	·150	·130	·162	+·103	4·6	5·4	+·80	21·91
.. ..	10	12·42	4	5	·328	·413	·102	—·132	4·25	4·05	—·20	25·81
.. ..	15	19·58	6	6	·074	·078	·091	—·008	4·9	4·25	—·65	19·55
.. ..	12	15·50	4	5	·100	·261	·125	—·304	4·6	4·05	—·55	19·02
.. ..	14	19·00	6	7	·086	·135	*Nil*	—·098	4·6	4·15	—·45	18·78
.. ..	15	21·75	6	13	·060	·189	·034	—·258	5·6	4·05	—1·55	21·64
.. ..	12	16·83	5	6	·092	·097	·112	—·010	4·8	4·4	—·40	27·12
.. ..	17	22·58	7	13	·057	·122	·075	—·155	5·1	4·25	—·85	24·76
.. ..	14	20·00	6	7	·027	·163	·054	—·247	6·15	3·9	—2·25	15·47
.. ..	12	13·00	4	5	·244	·318	·048	—·156	4·05	3·9	—·15	23·13
.. ..	10	14·58	3	6	·080	·087	·141	—·014	5·0	5·3	+·30	19·46
.. ..	17	21·17	7	8	·065	·154	·141	+·132	5·7	4·05	—1·65	21·00
.. ..	12	19·42	6	7	·100	·242	·129	—·184	5·2	4·15	—1·05	29·80
.. ..	6	9·33	1	3	·068	·064	·039	+·008	5·5	5·2	—·30	27·03
.. ..	11	14·17	5	6	·284	·347	·172	—·126	4·05	4·05	0	17·55
.. ..	7	8·42	2	3	·072	·124	·025	—·104	5·6	4·05	—1·55	25·18
.. ..	11	15·25	4	6	·092	·099	·098	+·028	5·2	6·15	+·95	18·22
.. ..	12	15·08	5	6	·316	·303	·106	—·144	4·65	3·9	—·75	14·74
.. ..	13	17·58	5	6	·120	·147	·090	—·044	4·4	4·1	—·30	14·29
ans	12·60	17·17	4·92	6·92	·139	·192	·098	—·086	4·87	4·37	—·50	22·30

Item 6 (b)—(d).]

APPENDIX II.

Part I.

Correlations with Heights of Trees and Girths of Trees.

		Heights of Trees.		Girth of Trees.	
		1932	1933	1932	1933
Compartment 11 ..	(*a*) Lime requirement percent surface soil (original.)	—·2572	—·2982	—·1655	—·2174
(26 soil pits)	(*b*) Lime requirement percent surface soil (after taungya).	—·04511	+·01249		
	(*c*) Lime requirement percent (mean whole profile original.)	—·1266	—·1857		
	(*a*1) N. KC*l* pH Surface soil (original)..	+·1637	+·2072		
	(*b*1) N.KC*l* pH Lowest sample (original)	—·2939	—·1927		
	(*c*1) N.KC*l* pH difference going downwards (original).	—·3910	—·3577	—·3652	—·2739
	(*a2*) S. P.—16% surface soil (after taungya)	—·2592	—·1926	—·2103	—·1573

Significance .. P = ·1 r = ·32
= ·05 = ·38
= ·02 = ·44

		Heights of Trees.	
		1932	1933
Compartment 12 ..	(*a*) Lime requirement percent surface soil (original).	—·2547	—·3908
(20 soil pits)	(*b*) Lime requirement percent surface soil (after taungya).	—·07347	+·09362
	(*c*) Lime requirement percent (Mean whole profile original).	—·1774	—·1622
	(*al*) N.KC1 pH surface soil (original) ..	+·2714	+·3071
	(*bl*) N.KC1 pH lowest sample (original)	—·1195	—·4922
	(*cl*) N.KC1 pH difference going downwards (original).	—·2622	—·5492
	(*a2*) S.P.—16% surface soil (after taungya)	—·4236	—·1042
	(*b2*) S.P.—16% surface soil (original)	—·1873	+·1654
	(*c2*) S.P.—16% mean whole profile (original).	—·1385	—·03329

Significance .. P = ·1 r = ·378
= ·05 = ·444
= ·02 = ·516

S. P. = Sticky point.

APPENDIX II.

Part II.

Combined correlations—Two seasons' growth.

	(Height of Trees)	
	R	P
1. Lime requirement percent surface soil (original) ..	—·3364	·05—·02
2. N.KC1 pH lowest sample (original)	—·3452	·05—·02
3. N.KC1 pH difference going downwards (original) ..	—·4442	<·01

Shorter Notes on Soil problems.

(*i*) *Assam.*—It is necessary, (*a*) to emphasize the relative importance of the mechanical and chemical analysis of soil, (*b*) to discuss if it is possible to correlate the physical properties with the *p*H value of a soil sample and the limitations of the use of the latter in solving the regeneration problem. Ordinarily *p*H is calculated from the samples of the surface layers but as the tree crop is dependent on the subsoil for the greater portion of their life, it may be necessary to work out the value from the samples taken at different depths before coming to any definite conclusion.—*C. S. Purkayastha.*

(*ii*) *Bengal.*—Our requirements are :—

(*a*) A simple field method of determining whether a soil is in a suitable condition for natural regeneration of *sal.*

(*b*) A simple field method of determining whether soil is suitable for planting other important species.

(*c*) Are recognisably different forest types associated with simply ascertained soil conditions ?—*C. K. Homfray.*

(*iii*) *Bihar and Orissa.*—This work should be undertaken in a small way with the object of studying the physical (and chemical) properties of the soils on which our main types of forest are found; and later on the preparation of soil maps. This will involve primarily the study of soil profiles and the mechanical analysis of the soils ; and secondly, if possible, chemical analysis.

To commence with, a study of the soils in various types of *sal* forest should be undertaken which could be extended to other types later on.

This programme of soil studies will have to be undertaken in a very small way in Bihar and Orissa and at present neither physical nor chemical analysis can be undertaken in Ranchi owing to the lack of electric power. This however is likely to be installed in the near future.

As regards staff it would be necessary to train a man (a P. F. S. officer or selected ranger) to carry out mechanical analysis. I can do this, It would not be a whole time job. During the touring season he could be employed on various field works and could do the laboratory work in the rains. All this must await the installation of electric current. Otherwise, it is suggested that a whole time assistant be appointed at Dehra Dun who could undertake to analyse samples from the provinces. But I think it would be more satisfactory (owing to the very slow and tedious nature of the work) for each province, if possible, to employ a whole time or part time officer.— *F. C. Osmaston.*

(*iv*) *United Provinces.*—No detailed soil studies have been made in the United Provinces, and this question has been raised so that we in these provinces may learn what has been done in other provinces, and to initiate a discussion on the value, nature and scope of soil studies in connection with natural regeneration problems. Where artificial regeneration or afforestation are being carried out, the value of preliminary soil study is obvious. An analysis of the mechanical and chemical nature of the soil, and most usefully the determination of the pH value, should indicate the suitability or otherwise of the soil for certain species, once the corresponding conditions under which the species occur naturally or in other plantations have been analysed. But in the case of natural regeneration, so many other factors are involved that the value of detailed soil studies seems perhaps a little doubtful. The various operations carried out to secure natural regeneration, such as fellings of various degrees, shrub cutting, burning, fencing, grazing, must all affect the soil, but in general it would appear much easier to determine the suitability of conditions for regeneration by the condition of the undergrowth, and also by the appearance of the regeneration desired, than by resorting to detailed soil studies. Although extensive natural regeneration experiments have been laid out in the *sal* forests of the U. P. during the last few years, no detailed soil studies have yet been undertaken, and for this reason the U. P. would like to learn what other provinces have done in this direction, or what line of action it is suggested might be taken.—*E. C. Mobbs.*

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Item 6 (b)—(d).]

(*v*) *Research Institute* (General note circulated) :—Provinces are mainly interested in three problems :—

(*i*) Can the development of different forest types be correlated with soil characters ?

(*ii*) Can the suitability of soils for natural regeneration be determined from soil characters ?

(*iii*) Can the suitability of soils for artificial regeneration with given species be determined from soil characters ?

If any of these questions are answered in the affirmative then simple practical methods applicable in the field by, say, an intelligent Ranger, are required for determining the characters in question. Three types of field work are suggested as likely to be practicable :—

(1) Ocular examination of soil profiles comparing them with standard profiles.

(2) Simple mechanical analysis.

(3) Field pH determinations.

It is evident that the horizon or depth or depths for which (2) and (3) are carried out, must be standardised

Practical studies on these points have been made in Burma and the Punjab and some of the results have already been published (*Burma For. Bull.* No. 25 and *Ind. For.* June 1934). These studies have given sufficiently positive results in two very different and important types of forest, to justify further work on the lines they indicate. They indicate in both cases that given the preliminary laboratory study to provide the necessary standards for comparison, useful practical deductions can be made from an ocular examination of representative profiles.

The Burma work has shewn that the height growth of *Gmelina* is definitely correlated with the variation of pH with depth. Determination of pH can be done colorimetrically in the field with a simple outfit, after a little practice.

As regards the fundamental work for each problem usually necessitating more or less analytical work, it is thought (B. & O.) that Provincial Silviculturists should have no difficulty in training one of their staff for pH determination and simple mechanical analysis but more skilled work must be done either through local soil experts (as in Burma), which is not generally satisfactory as anything more than a temporary arrangement sometimes possible, or through the Soil Chemist who should be available at the Forest Research Institute.—*H. G. Champion.*

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Notes on Root Studies.

(*i*) *Research Institute.* (Circulated).—The *Experimental Manual* describes (p. 83) two methods of examining root systems and refers to the works of Clements and Weaver in America for fuller details. The subject has been brought up in connection with *Root Competition* which is not specifically discussed in the *Manual* and specific problems mentioned are :—

(1) Relation of root systems and root competition between the chief and subsidiary species in mixed line sowings (Bengal).

(2) Relation of root systems and root competition between tree crop and soil cover crops (Bengal).

(3) Relation of root systems and root competition between overwood and regeneration in natural regeneration of *sal,* including rate of establishment and in both even-aged and uneven-aged crops (Bihar and Orissa).

Work on 1 and 2 is in progress at the Forest Research Institute and examples will be demonstrated in the field to the conference.

There are also experiments dealing with the effect of an underwood on an overwood of the same species for *sal* and *chir* pine, and on the effect of an adjoining *sal* crop on taungya line sowings which will be exhibited.

A closely connected problem is that of the effect of grass or a soil cover crop on soil moisture and this has been studied in the Punjab and the Forest Research Institute with interesting results.

A procedure might be given in the Manual for studying head 3 if it is thought desirable.—*H. G. Champion.*

(*ii*) *Bengal.*—In Bengal, we have now certain standardised species for mixed line sowing such as *Terminalia myriocarpa* with *Chukrasia tabularis,* and *Acrocarpus fraxinifolius* with *Chukrasia ;* also experiments are being carried out with intimate mixtures of other species. It might be of inerest to find out how the roots of the different species develop in relation to one another, and to see if the principal species concerned is suffering from root competition of the subsidiary species.

Also experiments are being carried out with different species for use as cover crop, it would again be of interest to study exactly how the roots of the cover and tree crop develop and to see if there is any root competition.—*C. K. Homfray.*

(*iii*) *Bihar and Orissa.*—It is suggested that some experiments be initiated to study the effect of root competition on (*a*) the general condition of regeneration (*b*) the rate of establishment of regeneration. The extent of its influence in even-aged and uneven-aged crops should be investigated. As far as this province is concerned the research should be limited to *sal* forest and might be carried out in crops of different ages.—*F. C. Osmaston.*

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PAPER (III).

Contributed by N. P. Mohan, *Deputy Conservator of Forests, Punjab.*

Value of the Plea for Ecological Survey for Problems of Natural Regeneration.

1. *Introduction.*—It should not be really necessary to stress the importance of ecological studies at this period of the twentieth century ; but their continuous neglect and lack of continued work on ecological basis is such a pronounced factor in the history of the development of the forestry in this country that no apology is needed for emphasising the value of the study of ecology, which is the recognised basis of land classification, agriculture, horticulture, pasture management and forestry. In no branch of the forester's art (silviculture) is the application of ecology so essential, as in the determination of the methods of natural regeneration and in no branch has it been more neglected and ignored. If the same attention that has been lavished on other branches of forestry, had been given to ecological research for purposes of obtaining natural regeneration, considerable advance would have been made in matters of which our knowledge is still superficial. While elaborate technique is being daily developed regarding the destruction of natural vegetation, (*cf.*, elaborate felling rules, logging and extraction technique, volume and yield tables and calculations, etc.) the essential art of getting regeneration established by nature is still largely relegated to the time honoured method of trial and error and to the preparation of a few abstruse forms. Empiricism and dogmatism are still the master factors which inhibit the growth and development of natural methods for establishing reproduction. Even the Forest Research Institute, Dehra Dun has yet to discover the justification or the means for the appointment of an ecologist. In the Punjab, Mr. Glover emphasised the need of ecological studies and the value of plant indicators in the Punjab forest conferences of 1930 and 1931 and his paper was followed by two papers in 1933 conference—one on spruce and silver fir by Suri and another on *Pinus longifolia* by Mohan and this sums up the ecological work done in connection with forest management in the Punjab. This note is therefore a plea for ecological research in general and for the study of natural regeneration on an ecological basis in particular.

2. *Our ignorance and its causes.*—Our ignorance of methods of obtaining or ascribing definite causes for failure and building up successional series to obtain natural regeneration is undeniable even in the case of principal species. Taking the Punjab species, no tried method is available for inducing natural regeneration of *Prosopis spicigera* and *Olea cuspidata*—valuable trees of the

Punjab plains and Salt Range respectively. The method of inducing regeneration by seed of *Populus euphratica* is still to be discovered. The methods of regeneration by seed of almost all the species of the low hill scrub flora are a sealed book. Regeneration problems of even *Pinus longifolia* are not as yet completely solved. Efforts to obtain regeneration of *Quercus incana* and *Quercus semecarpifolia* have been abandoned though persistent efforts are made to grow these trees artificially in areas where nature has failed to reproduce them. The reproduction of deodar under certain circumstances is not possible and means to bring the area to respond by developing a deodar crop are still open to investigation. The classic example of fir and spruce regeneration hardly needs any mention. It will be no exaggeration to say that our knowledge of succession and principal types of natural vegetation is of the shallowest and our methods of inducing regeneration (wherever we can) are those of a fatalist rather than those of a scientist. Natural regeneration is only obtained where the climax association has become stable but the practical forester should not delude himself that the stage or the state can be indefinitely maintained. A guess for the failure is made ; and the failed area is allowed to take care of itself or endless efforts are made to coerce it to yield what it cannot.

3. Solution of the problems of natural regeneration is a real necessity and the efforts hitherto have not always taken into consideration some of the salient factors of ecology and failure is directly attributable to the lack of ecological studies. Natural regeneration is nature's response to the factors of the environment. Nature is an old and experienced forester ; it has in natural and semi-natural vegetations grown and developed those associations which the habitat factors would permit. Every plant formation is *a stage* in the evolution of a climax association. Pioneer and other successive stages cannot stand the treatment which may be applied to climax stages and uniform treatment to all areas in different ecological seres is really a waste of time, labour and money. To arrest the succession at a certain stage (the most economic to the forester) is the key to problems of natural regeneration and ignorance of seral nature is the bane of practical forestry. It is the unqualified privilege of the forester (whose art depends on the rock of ecology) to disturb the natural and ecological adjustment of plant communities (without study and without knowledge of succession and retrogression) and then to blame nature for his own mistakes and ignorance.

4. *Rational method for solving the problem.*—Empirical methods have and should have no place in the practice of forestry and they should be replaced by scientific investigation, *viz.*. the determination of the habitat factors, the stage of succession, and the effect of past and present factors, processes and practices. All this is reflected in the vegetation (natural and semi-natural) of the region concerned and a study of vegetation supplemented by simple field experiments will not only place natural reproduction methods on scientific basis but will also solve problems which at present baffle an average forester. Nothing is easier than to quote instances where ecological study of vegetation might have saved expenditure and time which was expended in uselessly expecting the trees to reproduce themselves ; and there is no lack of areas where in the name of silviculture, measures were adopted which have thrown the succession to earlier stages from which the vegetation will take decades to regain the ground it has lost. But it is far more important to concentrate on future work and to profit by past experience.

5. Problems of natural regeneration are in ecological terminology problems of succession, invasion, zonation and alternation, which in their turn are associated with aggregation, migration, competition and re-action. Reproduction is the test of the success of ecesis which consists essentially of three processes : germination, growth and reproduction. Various plant communities—components of successional development—are responses to the habitat factors, practices and processes, the determination of which is a necessary prelude to the proper realisation of the cumulative effect of the environmental complex and to the evolution of practices and processes which will arrest the sere at a desired stage or maintain the climax at which the species (generally valuable economically) chosen by the forester are desired to reproduce themselves again and again. Natural regeneration is thus a practical problem of ecology and is capable of

being tackled and solved by true ecological methods. These methods are modified to suit the needs of the investigation and the succeeding paragraphs show in a general way how they can be so adapted and modified.

6. *Methods of ecological research as applied to natural regeneration studies.*—General principles of scientific work have been aptly summed up in the following sentences by Jevons in "The principles of Science" and they apply specially to ecological work :—

> "The true course of inductive procedure .... consists in *anticipating nature*, in the sense of forming hypotheses as to the laws which are probably in operation, and then observing whether the combinations of phenomena are such as would follow from the laws supposed. The investigator begins with facts and ends with them. He uses such facts as are in the first place known to him in suggesting probable hypotheses ; deducing other facts which would happen if a particular hypothesis is true, he proceeds to test the truth of his notion by fresh observations or experiments. If any result prove different from what he expects, it leads him either to abandon or to modify his hypothesis ; but every new fact may give some new suggestion as to the laws in action. Even if the result in any case agrees with his anticipations, he does not regard it as finally confirmatory of his theory, but proceeds to test the truth of the theory by new deductions and new trials ". In other words, inferences should be drawn from every observed fact and the descriptive and analytical phases should be kept in mind side by side.

7. In studying natural regeneration problems, it should be remembered that every plant community (not simply a single species) is one (though a complex) organism and possesses function and structure and passes through a cycle of development—the succession. Information is to be gathered regarding its formation, structure and succession and to determine the most suitable stage in the successional development where the natural regeneration of a selected species is easiest to obtain. Function comprises invasion, association and aggregation ; invasion can be resolved into migration and ecesis, while succession has to do with reaction on the habitat and vegetation and competition (both root and shoot). Structure includes study of zones, layers, consocies, societies, etc. (all included under the term zonation and alternation). Structural phenomena are immediate products of habitat, and of ancestral and historical facts.

8. It will facilitate collection of the data if the various items requiring investigation are given in tabular form. For purposes of natural regeneration, information is to be gathered generally on the following points :—

(*a*) Data relating to a plant community.

(*b*) Data relating to individual species, (*viz.*, of the species under investigation and its co-dominants and competitors in the different stratum societies including the different root strata).

(*c*) Data regarding direct factors of habitat, *viz.* :—

  (*i*) Soil—Soil profiles, minerological nature, soil moisture, soil texture, pH value, soil solutes.

  (*ii*) Light.

  (*iii*) Temperature.

  (*iv*) Atmospheric moisture.

(*d*) Confirmation of results by simple field experiments, pot cultures and in some exceptional cases by detailed laboratory practice.

It should be noted that the data under (*a*) covers the ground under (*b*) and both (*a*) and (*b*) serve as index of the value of (*c*) on the vegetation.

9. The following are the main points of the study of the plant community :—

(1) Structure.

(2) Zonation (vegetation zones).

(3) Alternation.

(4) Composition (spatial and vertical) of the different layers of association and seasonal aspects. It will include information regarding constant, exclusive, casual and indifferent species, their frequency and dominance. Means of maintenance.

(5) Life forms including vegetation, growth and habitat forms, *i.e.*, the physiognomy of the association as influenced by the regeneration of the component species. Ecads.

(6) Function.

(7) Aggregation (best studied on a new or denuded area).

(8) Reproduction.

(9) Migration.

(10) Invasion.

(11) Migration (including seed production, regularity or otherwise of seed production, fertility or otherwise of seed, vegetative reproduction, contrivances for dissemination, direction of dissemination and barriers if any).

(12) Ecesis (Germination, growth and development, and periods of such functions).

(13) Succession (including study of competition and reaction) :—

(14) Primary succession.

(15) Secondary succession.

(16) On different kinds of soils.

(17) On eroded areas.

(18) On landslips.

(19) On burnt areas.

(20) On felled areas ; and fellings of varying intensity.

(21) On cultivated areas.

(22) On drained areas.

(23) On water logged areas.

(24) On irrigated areas.

(25) Based on varying composition of different layers of the community.

(26) Correlation of the information gathered with reference to natural regeneration and evolution of treatment types for practical purposes.

10. Coupled with the study of the community will be the individual study of the species under investigation and other species in the community which compete with it in the invasion and in the regeneration of the area. This will involve phenological and morphological studies while the means adopted by the species for their adjustment to the habitat will receive special attention. Determination of plasticity or fixity of various parts of the plant structure under different situations will reveal valuable information regarding the nature and intensity of habitat factors. Ecads should therefore be discovered, if possible, both for the assessment of the value of the more powerful factors as well as for conducting pot culture experiments for confirmation of the results.

11. To collect this mass of information is by no means difficult though patience is essential. It is only to the dabbler in scientific investigations to whom the work will appear a drudgery. For the discovery of master factors that control the regeneration of the species under investigation, the aim is to make a complete list of the stages of succession to determine the most desired stage and so to modify the factors that as far as possible the sere does not proceed further. The practical procedure for the collection and tabulation of the above data is described below. It is useful to have pages allotted to the 26 different heads given above and to record information under each head from the commencement.

12. The first stage is a general reconnoitering of the area. This reconnaissance should cover as much of the area of the species under investigation

as possible, and should gather general information regarding every well-marked type of natural or semi-natural vegetation, dominant and abundant species, or any peculiar species, and general type of soils. This is followed by Primary Survey. This survey is of very great importance in the study of the phenomenon of natural regeneration. It has for its objects :—

(*i*) The classification of the region into broad forest types based on an associate (or associates) of the species under study in one of the layers of vegetation or if this is not possible the types are distinguished on the nature of the soil.

(*ii*) The preparation of lists of the principal associates of each type and rough and inferential correlation of the presence or absence of any communities or plants with habitat factors, past or current practices and processes and the communities. The areas of secondary succession are examined and their structure analysed. Frequency and aspects (seasonal changes) are noted for the principal components.

(*iii*) Selection of areas in each type where natural regeneration was established by nature (normal areas) and of such areas where it could not be established and where it was deficent.

(*iv*) Marking out the position of the ecotone, migration circles, typical areas showing alternation (if any) of and in each type.

(*v*) The preparation of rough and probable successional stages with the help of the above data or the preparation of successional stages based on life forms if that is possible.

(*vi*) Phenological observations of the dominant species in any layer.

(*vii*) Selection of particular plant communities in which regeneration of the species under investigation is profuse, deficent or absent. Such communities are studied at as many places as possible within the same type and compared with one another. Such communities will not agree in every detail and the small differences will give clues to the changes in the environmental complex as affecting the regeneration problem and give rise to valuable inferences.

(*viii*) Influence of any animals which affect natural regeneration of the components of the dominant vegetation.

13. Primary Survey does not require any special instruments other than those with which a forester or a field botanist is normally equipped. Keen and quick observation and an imaginative mind are, however, essential.

14. To treat all the 26 heads mentioned under paragraph 9 will result in the compilation of almost a complete treatise on Ecology. The work in this province has not generally gone beyond the stage of Primary Survey, and reference to the two papers. " A study in the ecology of silviculture of the Himalayan spruce (*Picea morinda*) and silver fir (*Abies pindrow*) with special reference to works in progress in Kulu " by Suri and " Ecology of *Pinus longifolia* with particular reference to Kangra and Hoshiarpur Forest Divisions " by Mohan, presented at the 1933, Punjab Conference will show the points (out of the 26 above) on which material was collected and analysed and the points on which little or no information was available. These two papers may be taken as annexures to this note. The observations recorded therein are, therefore, not repeated here.

15. Results of primary survey point out lines of attack and intensive study begins with the laying out and charting of quadrats for studying succession on natural quadrats and denuded quadrats. The word quadrat, in this note is used in a general sense ; it is intended to include (to avoid redundancy) transects, ecotone charts, migration circles, etc. The principles of study in all of them are the same. The following points regarding quadrats are of importance :—

(*a*) *Location of quadrats.*—Standard quadrats are laid out in the norm, *i.e.*, areas where natural regeneration is abundant—a feature which represents the ultimate aim. They represent the standard with which other quadrats are compared. Series of quadrats are laid in each type distinguished by primary survey up to ecotone belts, both on the sub-climax and post-climax side. These quadrats are meant for the study of succession from the point at which a particular species enters a zone up to the point it leaves it. Quadrats are extremely useful at the place of the change of the zone and also in sub-zone of the particular forest type ; in alternes along with the intervening area ; in areas having seed bearers exhibiting different life forms and in migration circles and in all the places listed under 16 to 25 of paragraph 9.

(*b*) *Size of quadrats.*—Anything less than an acre will not be found to be very useful for purposes of regeneration study.

(*c*) *Scale of charts.*—It is almost impossible to chart the whole of vegetation over one acre on one convenient chart but the seed bearers and the shrub growth can be shown on the usual scale. For charting the herbaceous vegetation, principal colonies and societies can be shown on the same map, but for detailed study the standard quadrats (within the big quadrat) will be necessary. Every year the quadrats are re-charted and thus the successional study is continued.

(*d*) *Soil investigation.*—The soil of the quadrat (or of similar area in the immediate vicinity) is examined and information regarding profiles, mineralogical nature, soil moisture, soil texture, pH value and soil solutes is gathered by the standard simple laboratory methods. Effort is made to correlate them with vegetation. In soil profile studies, the profiles having abundant root development require the most intensive study as they are the centres of nutrition which plants have discovered.

(*e*) *Profile charts.*—These charts should also be prepared for the more important quadrats as they alone make the study of root competition possible. They will be necessarily not near the quadrat but an independent series of such charts is essential.

(*f*) *Denuded quadrats.*—Near the permanent quadrats, after the vegetation has been mapped, the entire plant growth is destroyed and the succession is observed in such denuded quadrats.

16. Information is gathered in each quadrat on points 4 to 13 of paragraph 9 and the quadrats are visited as often as possible and charted, the latter being done at least once a year. As soon as a particular quadrat comes to have the vegetation of another quardat, it can be discontinued as the one stage has given rise to the next. In this way a whole series is built up ; and even in case the whole series cannot be built up, some of the intermediate stages can be more or less correctly guessed. The sere at which the regeneration of the desired species occurs, is the sere at which natural regeneration is the easiest to obtain. The controlling factor of this sere can be easily deduced from the information gathered on points 4 to 13 of paragraph 9 ; and it becomes a simple matter to answer the following questions with regard to the species under investigation :—

(*a*) How is a certain community formed, how does it become to have a certain structure and how does it develop ?

(*b*) How does a certain species become dominant or abundant in some places and not in others ?

(*c*) What are the natural relations of species ?

(*d*) What are the weapons with which the various species fight ?

(*e*) What are the advantages or disadvantages they confer on one another ?

(*f*) What are their reactions to the different factors of the habitat ?

(*g*) What are their limits of tolerance of varying conditions ?

17. Having deduced such factors, it is essential to confirm their effect by simple field experimental methods. If light appears to be the controlling factor, regeneration fellings of varying intensity in the same set of observation plots (same vegetation) will confirm or contradict the results ; if moisture and soil texture control the regeneration, increasing the moisture content by closures

will reveal convincing results. In field experiments the use of instruments is obligatory. The effect of master factors must be expressed quantitatively and this opens up a vast field of research, not yet started in this province.

18. Another method of determining the effect of master factors is by the growth of ecads both in the field where one master factor (or two or more such factors are) is controlled and in pot cultures under as natural conditions as possible. The intensity of factors is measured by instruments and the effect (morphological or physiological) produced on the ecad is also studied by as exact instruments as can be devised. Pot cultures are invaluable for seed study. This again is a subject which has received scant attention so far.

19. Having completed the successional studies and correlated and confirmed the influence of habitat factors or regeneration, the causes of absence or presence of regeneration can be stated with perfect certainty. Causes having been known the remedy will be suggested by the successional study but the practical forester is anxious to hasten the course of succession to reach the sere at which the reproduction will be easy and not to permit the sere to go beyond and at the same time to keep the vegetation healthy. This is now successfully done in some cases in silviculture but generally in areas where throwing back the succession by burning the accumulated humus and brushwood is possible. The knowledge about such operations is fragmentary for many communities and not at all complete for many species. When satisfactory methods are discovered, they will, it can be confidently stated, owe more to ecological and vegetational studies than to any other single factor.

20. *Conclusion.*—Such is the general course of ecological work with reference to regeneration, *i.e.*, from the general to particular or for practical work from particular to general ; and such is the state of our knowledge and the stage of ecological research in this province and perhaps in other provinces. The problem is complex and our knowledge scanty. The work cannot be left to the care of a few who study it as time or opportunities permit. Ecological work must come within the ambit of routine research work and it is hoped that parts relating to Ecology in our Experimental Manual will be so revised as to give all the essential details for up to date ecological research work and the provinces will employ some of their officers on such studies. Standard methods, suited to every problem have not as yet been evolved in Ecology and perhaps will never be evolved on account diverse nature of the problems, but the very diversity and complexity of the subject demands early attention.

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Notes on Ecological Investigations.

(*i*) *Assam.*—The importance of the study cannot be over-emphasized and it is suggested that the division of the forests in general into definite types must precede all other work in this direction. Recognition of the forest type and its place in the progressive succession towards the climax stage is essentially necessary inevolving a technique for natural regeneration. In this connection a convenient method of describing a forest type may also be discussed.—*C. S. Purkayastha.*

(*ii*) *Bengal.*—We have laid out 15 miles of Linear Sample plots one chain wide traversing all the important forest types, identifying and measuring all trees over 4″ diameter. These lines have been sub-divided into the few main types standardised for working plans, and the percentage composition for a given type in the several lines has been examined. So far it has not been possible to arrive at any useful generalisation for a statistical differentiation of the types. The small trees, undergrowth and soil have not been examined.

Suggesions for further investigations.

(*i*) It is felt that further examination of the statistics already available for these lines might lead to useful results.

(*ii*) A simple method is required for investigating the undergrowth in relation to the types differentiated for the tree crop, and to the regeneration of the important species. It should also be possible to correlate Forest Types with soil characteristics and to this end the floristic composition should be recorded for the immediate vicinity of every soil sample investigated in this connection.

(*iii*) These lines have in practice been found insufficient to include samples of satisfactory regeneration of important species and so require supplementing. It is suggested that ecological study (floristic composition) of quadrats in such regeneration should be compared with similar quadrats in which conditions as regards seed-fall, light intensity, etc., appear equally favourable but regeneration is absent. It would be anticipated that the successfully regenerated quadrats would present certain features in common differentiating them from the unregenerated ones, and that when the same features were met with in the absence of seed trees the species in question could be introduced artificially with some confidence of success.—*C. K. Homfray.*

(*iii*) *Bihar and Orissa.*—It seems that ecological studies could very well be carried out in Preservation Plots, especially if these are moderately extensive (say 20 acres or more) ; or in connection with the transects or linear sample plots.

If ecology is to be undertaken as a study *per se* it would require more time and staff than could be devoted to it in this province. However, by far the simplest and cheapest method of carrying out general investigations would be for D. F. O.'s to take an interest in the matter and to maintain their compartment histories with great care and attention to detail. A well maintained compartment history would be invaluable in tracing the history of the vegetation of that area, whether it be one of progression or stability. This is also a matter for Working Plant Officers to see to.

As a special study and one that might be undertaken with profit, it is suggested that an investigation be made to determine the chief indicators of conditions favourable to *sal* regeneration in the main types of *sal* forest. The best indicators will generally be herbs or grasses in the ground flora. It should be possible to determine a definite connection between certain species and the presence of *sal* regeneration in its different stages. When this relationship has been established, as no doubt it can be, the next stage would be to find out the conditions necessary to the presence of these species and how to bring them about where absent.

A second investigation, which might be undertaken is to classify our bamboo forests and to determine as far as possible the conditions most favourable to their growth.

Another work, which it is thought might be undertaken is an ecological classification of the various types of forest found in the province. The descriptions might be prepared on a standardised form, so that if it were decided to extend the investigation to other provinces all would be compiled on the same lines.—*F. C. Osmaston.*

(*iv*) *Bombay.*—(*a*) So far as I am aware no special studies of the ecology of the tropical evergreen forests of Bombay have been attempted but possibly Mr. Inder, Conservator, Central Circle, may have done some work on this in Mahableshwar and Bhimshankar. From my own very limited observations the type gradually deteriorates from true tropical evergreen in the south round Gersoppa to the very poorest type of evergreen scrub round Trimbak. How far this change may be due to climatic differences and how far it may be the result of heavier imposition of biotic factors cannot be stated without a fairly detailed investigation. My personal opinion is that biotic factors have probably exerted a far greater influence than they have been credited with. For instance Talbot's "Note on the distribution of the Forest Flora in the Bombay Presidency " at the beginning of Vol. I of his Flora describes the Mahableshwar forests as " elfin-wood possessing all the characters of alpine evergreen ", without any indication that it may very probably be a subseral stage of tropical evergreen initiated originally by fellings made to get fuel for the primitive iron works which existed on the plateau from very early times. In this connection I quite agree with the suggestion made in the note that comparative studies along the evergreen belt would be of the greatest value for drawing up a general classification for the West Coast rain forest. Neither Ratnagiri nor Kolaba however, come within this zone. The places in Bombay at which this study could best be conducted are in my opinion, from south to north, Gersoppa, Gund, Helvak, Mahableshwar, Bhimshankar and Ghatgar.

Exploitation of the true tropical evergreen forests of Bombay has been negligible and consequently no experience with either natural or artificial regeneration can be recorded. Exploitation has been fairly continuous round Mahableshwar and in parts of Poona division, and the. Working Plans for these two areas, which have recently been revised, will give such information as is available on the present situation there.

(*b*) The science of ecology, consisting as it does in application of method and tabulation to the study of the fundamental natural processes upon which all forestry is based, is of value rather to the individual, in clarifying his ideas, than in any direct application. Though its influence should permeate most of our experimental research, there do not seem to be any particular subjects, or groups of subjects, which could be definitely isolated under the heading "Ecological investigations" in the Experimental Manual. As pointed out by Toumey (Preface to Foundations of Silviculture p. vi) the great advantage of the ecological concept towards biological forest facts, useful in the understanding of the forest and to serve as a foundation for the practice of silviculture, lies in the recognition of forest communities and in the appreciation that they are not fixed units but are in a constant state of change. The more profound the forester's knowledge of the life of the forest in all its aspects, the less the difficulties he encounters in his practice of silviculture. "A forest is an exceedingly complex biological unit. It comprises not only a more or less diversified aggregation of trees, but numerous species of shrubby and herbaceous plants, fungi, insects, herbivorous animals and a complex soil flora and fauna. In other words it consists of a very large number of mutually interacting organisms which are affected by, and themselves affect, a complex of environmental factors ". The special value of ecological surveys is felt in the preparation of working plans, for which they form a valuable, and perhaps essential, preliminary. This has always been indirectly acknowledged in the form in which the working plan document has been prescribed. The whole of Part I really consists of a summary, and appreciation, of the various factors affecting the particular forests for which a plan is being prepared. Knowledge of the principles of ecology is therefore of great value to anyone concerned with the preparation of working plans. In ordinary divisional practice the value of the ecological concept is chiefly in circumstances where changes in influential factors are occurring or liable to occur. As pointed out by Troup (Silvicultural Systems p. 183) "the development of ecology as a science has given a special impetus to the study of the physical and physiological conditions bearing on natural regeneration. In ecological language regeneration fellings are nothing more than a process of stimulating succession of a required kind. In order to achieve success, it is necessary to study the conditions under which this can best be effected by a partial or complete removal of the forest cover, resulting in the reduction of root competition, the admission of light, warmth, and precipitations, and the alteration of soil conditions." Another practical problem, the solution of which may be much facilitated if approached ecologically, is the question of grazing in forest land. Appreciation of the differences in the problem under different climatic conditions and of the proposition that grazing, like any other factor, may be not only not harmful, but actually beneficial under certain sets of circumstances, must involve a considerable modification of the forester's traditional attitude. The possibilities of using fire deliberately on moister sites in order to retard progression might also be suggested by an ecological examination. The whole practice of forestry assumes a new aspect when regarded simply as the planned manipulation of all the factors influencing vegetation, in order to modify the latter to suit man's requirements.—*E. A. Garland.*

(*v*) *Forest Research Institute* (Summary note circulated).—Notes have been received from Punjab, Bihar and Orissa, Bombay, Bengal and Assam. It is now generally realised that much of the scientific practice of forestry is applied ecology and a knowledge of the ecological factors and processes involved is essential to a proper understanding and solution of such outstanding problems as difficulties in obtaining natural regeneration, and the effects of forests grazing and fire policy. It is now also seen that in many instances, the forester's problem is to bring his forests to a certain stage in their natural succession or to keep them there, and to do this, he must know what that natural succession is and how the different controllable factors affect it.

Opinion differs, however, as to how far our forest research staff can or should go in the matter. Mr. Mohan (Punjab) makes out a case for very full and detailed ecological studies of regeneration problems, taking the position that we cannot afford not to make them and that the *Manual* should " give all the essential details for up to date ecological research work ". Mr. Garland (Bombay) considers they are " of value rather to the individual in clarifying his ideas, than in any direct application ", and that there do not seem to be any particular subjects which could be definitely isolated under this heading in the *Experimental Manual* ".

The matter of arriving at a scientifically based classification of forest types and subtypes is repeatedly mentioned and there will be general agreement that this could and should be taken up on standard and co-operative lines. In a given type, the correlation of the composition of the ground flora and the relative suitability for natural regeneration is called for, and similarly for suitability for artificial regeneration with other locally important species. That these factors should further be correlated with those of the soil is pressed under the head of " Soil Studies ".

The potential value of linear sample plots for studies of type classification and of natural regeneration has been stressed but Bengal points out that their 15 miles of line laid out at random have proved inadequate to include all the variations in regeneration conditions which are needed for study, so that the lines must be supplemented by others laid out expressly to traverse selected conditions. Success has not so far been attained in using statistical analysis of the stocking data for differentiation of types, but this point calls for further study (Bengal).

It is suggested that well maintained Compartment Histories should in time provide valuable records of successional history (Bihar and Orissa). This may be doubted owing to the size of our compartments and the practical impossibility of objective methods of recording, except of course as enumeration results at long intervals.

It would appear that the section of the *Experimental Manual* (pages 73—81) dealing with Ecology should be expanded sufficiently to provide a general guide to research work on the subject for those not already familiar with it ; it should include a glossary of ecological terms in use if this is not given in the *Glossary of Technical terms for use in forestry*. It is unlikely that detailed ecological studies can be taken up as routine work by those Silviculturists not already qualified and trained for it, but it should be realised that such studies are likely to be essential to the solution of many important regeneration problems necessary to forest management on up to date lines, and where these problems are most prominent, it will probably be necessary to post to the Research staff a duly qualified worker in this field.—*H. G. Champion.*

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Report of Debate.

The President.—I am very sorry to say that Dr. Mackenzie Taylor is ill in bed and the doctor has prohibited him from coming here today. But Dr. Puri, his Assistant, will deal with Dr. Taylor's paper and will tell us later all about the pH values of soils, a subject about which we foresters know very little indeed but about which we are very anxious to learn.

Mr. Garland.—Mr. Champion in the note he circulated summarising the suggestions received by him, considered the scope for soil studies under three heads as questions of general interest for all provinces. These he stated were (1), Can the development of different forest types be correlated with soil ? (2), Can the suitability of soil for natural regeneration be determined from soil characters ?, and (3), Can the suitability of soils for artificial regeneration by given species be determined ? It seems to me that the actual studies required to answer these three questions can in the same way be tabulated under three heads. (1) studies, perhaps on rather broad lines which are required to elucidate the conditions of forest soils where the presence of different forest types has established a more or less continued equilibrium between the soil and the vegetation ; (2), a very much more detailed study which is required to elucidate the modifications in the existing soil, which provide the conditions necessary to regenerate naturally either the whole of the natural vegetation or some particular components of it ; and similarly (3), a detailed study which is required to elucidate the further modifications necessary to enable artificial regeneration of a given species to be successful.

Taking the third point first—the artificial regeneration of a given species—it generally occurs, or very often occurs, that the particular species is a component of the existing crop which it is intended to replace, and therefore presumably there must be some relationship between the soil conditions which are required for the artificial regeneration and for the natural regeneration of the existing species. In artificial regeneration the treatment which the forest soils require approaches very nearly to that given to arable agricultural soil, the natural structure of the soil being altered by providing it with increased aeration and consequently increased biological activity. Anything that hastens the decomposition in the soil of organic matter also favours increase in soil fertility. A fertile soil is distinguished from an infertile soil not by the fact it contains more nitrogen, potassium or phosphorus, but by the fact that those particular nutrients which are present are liberated with greater rapidity in fertile than in infertile soil. Thus such treatment as liming or cultivation of the soil not only produces a favourable physical and chemical condition for plant growth but also more favourable conditions for the organisms which effect a more rapid liberation of soil nutrients. It also appears that factors which are critical for plant growth are more often physical than chemical but that the latter are sometimes of critical significence and that it is important to know their characters and properties. In the same way climate and topography are of immense influence and importance, and radically modify the effect of the litter which is being annually added where forest crops are present. It seems, therefore, that the correlation of the different forest types can almost certainly be obtained. This comprising as it does one of the most important facts of all ecological investigations is urgent, and it should be started as soon as possible.

Again, as regards the soil characters necessary for artificial regeneration. This information should be obtainable and possibly more easily, because a good deal of the work that is being done in agricultural research should be directly applicable to it and somewhere between the two (the agricultural research method and the broader correlation of the forest types) lies the necessary process for investigation natural regeneration, and that between those two lines you might eventually achieve the third. I had, as a matter of fact, a suggestion with regard to what seemed to me all that this conference should do at the present moment in regard to the passing of a resolution and that was the suggestion that the conference might urge upon Government that the absence of any appointment of a specialist of the Forest Research Institute for soil and chemical research is a serious handicap. I do not know that we can go very much beyond that at the present moment.

Dr. Puri.—I am sure you will all join with me in thanking Mr. Trevor for bringing forward this question of forest soil investigation for discussion. We have been mostly dealing with agricultural soils and the investigation of forest soils is a new experience for us, but we do know that a lot of work on forest soils has been done in other countries, mostly in Russia. We know that soils are derived from rocks and that forests develop with them, so that the type of forest that exists at a particular place is the resultant of all the natural conditions, mostly climatic, that have been in play during its development, and at the same time the particular type of soil that has come into existence has also developed side by side with the forest, so that there must be a very intimate relation between the type of the forest and the type of soil. The first work that we did, about which I propose to speak in the afternoon, was classifying in a general way certain types of soil. I must warn you that it is a very critical study and simply shows you that the problem is very important and likely to be of great economic value too. It appeals to us as scientists because it opens out new and interesting fields of work where we may hope to gather and add to the knowledge already existing. I hope you will pass a strong resolution urging the necessity of these soil studies for regular forest problems.

Mr. Mohan.—As regards principle, the proposal so far as it goes is a very sound one but it is not sufficient. By way of example, when the soil of the plantations in the Punjab came to be analysed the work could not be done at the Forest Research Institute because it would have taken two years. The obvious deduction is that there should be workers in the provinces too. I do not think there should be an institute established in each province but a certain amount of work can be done in the provinces, and I believe there are officers available in every province who can be utilised. I would urge that the resolution should also state that the provinces should do some sort of work on the spot. At the same time I would suggest that not only is chemical analysis necessary, but particularly in regard to the soil from the plains, mineralogical and ecological analyses are far more important than the mere finding out of the pH value or organic content. In fact I have been doing this work for the last six months—with very simple apparatus, of course : a compound microscope with a polariser is required and such instruments should be made available. Not only is systematic work necessary in the field but there should be some sort of provision for advice ; in the Punjab we always go to Dr. Mackenzie Taylor for any assistance we need. Correlation of soil with vegetation is an established fact, and the soil constituents can in some cases be easily correlated with the vegetation on the ground, but the study of the latter is more important than the soil study. We should concentrate first on natural vegetation and classify the types and then correlate them with the soil. The two studies should go hand in hand, but as trained foresters we should take up the vegetational study first.

Mr. Mobbs.—I think that I am voicing the opinion of everybody here when I say that we all realise the great importance of soil analysis where artificial regeneration is concerned. I can give a case in my own experience in which a certain *sissoo* plantation was required by the working plan officer to be extended, but unfortunately it was not foreseen that the persons who would extend it would not extend it in the right direction. When it comes to natural regeneration, there is probably very considerable doubt in the minds of most of us. Mr. Mohan draws the conclusion, and I agree with him, that ecological study is probably of greater importance than soil study in the first attempts to study natural regeneration, but we must not forget that soil study is a very necessary corollary to ecological study, and I very much hope that Dr. Puri will explain to us how he thinks soil analysis could possibly be effected and be taken up scientifically in connection with natural regeneration. We know that where natural regeneration cannot be obtained the soil probably has something to do with it. Mr. Trevor himself will tell us that in the hills, deodar, fir and spruce forests, regeneration is often not obtained. But in many cases, *sal* regeneration in the United Provinces is already on the ground and we simply do not know how to get it up. If soil analysis can help us we should not only be very grateful, but we should spend a great deal of our time and money undertaking this regeneration, and what we really want to know is whether this can be done or not.

A further point which might be mentioned is that a good many of us are not quite sure what are the best methods of soil analysis. I have myself here a catalogue of a large number of soil analysis apparatus and I am really rather confused to know which one to use myself. I think therefore the conference should emphasise the necessity of soil analysis for artificial regeneration. It should also emphasise its necessity for natural regeneration and the necessity for training people in every province in methods and apparatus of soil analysis.

Chairman.—(Exhibited some soil profiles taken by Dr. Mackenzie Taylor shewing the connection between an excessively deep A horizon and failure of coniferous regeneration).

I personally have been more than anxious that investigations of this sort should be started by us and brought to a fruitful conclusion. I am perfectly certain that in many cases some of our problems can be solved, or at any rate very valuable information can be obtained, by the use of a proper scientific method of investigating the soil, and I would cordially support the remarks of Mr. Mobbs that it is absolutely essential that the Forest Department should start investigating soil problems.

Mackenzie Taplor's address was delivered at the previous Session. See pages 71—78.]

Discussion on Dr. Mackenzie's Address.

Mr. Mohan stated that the practical worker requires to know the depth to which to carry his investigations, which is not obvious in the deep alluvial soils of the plains ; he enquired if one should concentrate on the horizon in which the tree roots were most prevalent. *Dr. Puri* replied that the depth must be settled for each investigation.

Mr. Mohan further enquired whether a suitable auger could be recommended as pits were expensive, but *Dr. Puri* said pits should be dug. *Mr. Mohan* referred to the changes of pH value at different depths with seasonal changes ; *Dr. Puri* explained that *distribution* of pH value remains determined by the soil type though the absolute values may vary with season. *Mr. Mohan* stressed the necessity of recognising growth forms within a species, and of bearing in mind the existence of migration barriers when attempting to draw conclusions from the absence of certain species.

ITEM 6 (*e*).

Research in Irrigated Plantations.

A paper was contributed by Mr. *Parma Nand Suri*, (Punjab) and circulated to officers in Sind as alone likely to be concerned. *Mr. E. C. Mobbs* (United Provinces) in opening the debate proposed that unless the Punjab wished to discuss the subject, the conference, whilst recognising its importance, should leave the Punjab to take it up themselves, keeping in touch with the Central Silviculturist. *Mr. Champion* referred the Conference to the Punjab *Irrigation Manual* by Bahadur Singh, and *Mr. Garland* (Bombay) said that Sind officers expected to profit from Punjab experience but were not in a position to add anything at present.

The following resolution was proposed by *Mr. Mohan* (Punjab) and seconded by *Mr. H. L. Wright* (North-West Frontier Province), and adopted.

RESOLUTION ON ITEM 6 (*e*).

RESOLVED that—

This Conference recognises the importance of problems connected with irrigated plantations, but considers that owing to the great differences of conditions, the problems can only be satisfactorily dealt with by the Provinces concerned. The Central Silviculturist should continue, as at present, to keep himself acquainted with progress in the Provinces and to give advice or suggest co-operation where it appears that different Provinces are dealing with similar problems.

PAPER (I).

Contributed by PARMA NAND SURI, *Punjab Forest Service.*

Special problems of irrigated plantations and research methods for their in-

The subject of this note is an almost exclusive concern of the Punjab at present, though Sind will soon be equally interested in it. The history of irrigated plantations in the Punjab dates back to 1866, when the now well-known Changa Manga plantation was started. There are, at this time, 8 plantations, covering an area of about 80,000 acres, some well established and others still in the formation stage.

2. As a result of experience gained in Changa Manga, a technique for the formation of irrigated plantations was evolved and followed in raising new plantations. It was fairly successful with minor modifications, where about the same conditions of climate, soil and canal water supply obtained as in Changa Manga. But in plantations with climate and soil approaching desert conditions, and canal water supplies deficient and irregular, drastic changes in lay out, choice of species, methods of stocking and irrigation had soon to be made. Trial and error methods of investigation were adopted and a great deal was again learnt by experience. The organised research work in irrigated plantations did not start until 1927-28, when a large number of volume and comparative thinning sample plots were laid out by the Forest Research Institute, Dehra Dun, in *shisham* (*Dalbergia sissoo*) crops, and a few experiments on water requirements of *shisham* on different soils, on *shisham* planting espacement, etc., were started in consultation with the Forest Research Institute by the territorial staff at Chichawatni. As a result of these experiments, a considerable reduction in the use of water was made possible, but there was still a great deal to learn. So in 1930, investigations into deep and shallow watering were commenced in Chichawatni, and in 1931 large scale experiments on the optimum water requirements of several species were started in Khanewal. Investigations at Chichawatni have already given some provisional results, but in Khanewal, experiments on species other than *shisham* (*Dalbergia sissoo*) and *farash* (*Tamarix articulata*) had soon to be given up as those species (*Acacia catechu, Melia azedarach, Acacia senegal, Zizyphus jujuba*) were found unsuitable for original stocking in plantations. The Khanewal experiment has, however, made it quite clear that soil is a more potent factor than

water in irrigated plantations, and that in all water investigations it is essential to eliminate the soil variation factor, if reliable results are desired.

3. The special problems of irrigated plantations now confronting the plantation officers in the Punjab are :—

(*i*) The soil problems,
(*ii*) The species problems,
(*iii*) The irrigation problems, and
(*iv*) Miscellaneous problems.

The above problems, except the last, are mostly inter-connected and the success of the new plantations largely depends on their investigation, based on sound scientific research methods. Problems under each head and research methods for their investigation are discussed in the following lines.

4. *Soil problems.*—Soils in irrigated plantations, as elsewhere, vary greatly in depth, quality, and composition, resulting in several types of soil, which, in the absence of soil indicators, are hard to distinguish in the course of afforestation : the indigenous vegetation is removed and the area is generally leased for cultivation before afforestation takes place. In the absence of a satisfactory soil classification and practical methods of recognising soil types in the field, the choice of species for and their irrigation in various types of soil becomes difficult and often mere guess work. Soil problems of irrigated plantations requiring investigation, therefore, are :—

(*i*) classification of plantation soils into types,
(*ii*) practical methods of distinguishing various soil types,
(*iii*) suitability of soil types for plantation species,
(*iv*) suitability of soil types for normal irrigation, and
(*v*) reclamation of soil types found unsuitable for plantation.

Soil classification is by far the most important problem, as on its solution depends largely the investigation of the remaining soil as well as species and irrigation problems. Soil classification can be done either by (*a*) a partial soil survey or (*b*) a full soil survey.

(*a*) *A partial soil survey.*—The following classes of soil are generally met with and distinguished in '*Bar*' lands on which irrigated plantations are being raised in the Punjab :—

(*i*) Sand.
(*ii*) Sandy loam.
(*iii*) Clayey loam.
(*iv*) *Kallar* soil—
    (*a*) white *kallar* soil,
    (*b*) black or brown *kallar* soil.
(*v*) *Rappar* soil.
(*vi*) *Bara* or *Bari* soil.

As soon as the site of a proposed plantation is selected, and before the indigenous flora is removed, a soil and vegetation survey of the area should be carried out. The soil survey will be based on close surface observations of the soil in the first instance, and all classes of soil met with, as distinguished above, will be carefully demarcated and their boundaries plotted on large scale (32" = 1 mile) detailed topographical and rectangulation maps. All vegetation (trees, shrubs, herbs, and grasses) growing on each class of soil, singly or in groups, will also be plotted on the soil maps. A suitable number of pits (2½' × 6'). sites for which will be carefully selected by an expert, will be dug up in each class of soil and vegetation type, down to sand layer or hard pan, and their position shown on the map. The profile of each pit will be examined and observations on soil texture, structure, moisture conditions, colour, root penetration, etc., recorded on prescribed forms. Soil samples will then be taken from each horizon and their approximate pH. values determined in the field with the help of B. D. H. Universal Indicator or some other suitable field apparatus. Soil samples from a few selected pits in each type of soil, subsequently be analysed in detail by a soil chemist for their exact pH values, chemical, mechanical and physical composition. This study will give a fair knowledge of the depth, composition and degree of alkalinity of each class of soil, and with the help of the soil survey map, it will not be difficult to distinguish them at the time of stocking and to determine their suitability for plantation species and irrigation, after experimentation and a detailed study of indigenous flora in relation with soil types.

(*b*) *A full soil survey.*—The method of full soil survey differs from the above mainly in this respect that the classes of soil mentioned above are not taken as the basis of the survey but soil types are evolved independently as a result of accurate soil survey, study of soil profiles and complete analysis of soil samples from a much larger number of sample pits, carefully selected and well distributed, say every 500′ apart.

The method of full soil survey is admirably described in Imperial Bureau of Soil Science, Technical Communication No. 15, and may be consulted.

A joint discussion of the data by the soil chemist and forest officer will facilitate the decision on soil types, which may be distinguished on the basis of depth of soil, its composition, degree of alkalinity, etc., etc. When this is done, their distribution will be shown on soil maps.

When detailed soil survey maps are available, each type of soil can easily be located on the ground before afforestation, and dealt with accordingly. In case of need, however, for the determination of the soil type of a particular area, soil sampling will be done and the type determined : there seems no other practical method for this purpose in the case of areas devoid of vegetation. As regards the suitability of each soil type for plantation species and irrigation, knowing the depth, quality and composition of the type, the investigation becomes fairly simple. On soils with a sand layer or hard pan of *kankar*, or stiff clay close to the surface, only shallow rooted and xerophytic species will, of course, be planted, and to avoid water logging, such soils will not be excessively watered. Such well-known principles, coupled with experimental sowing and planting, and a systematic study of the root system, will make the choice of species for each type of soil very easy. The soil profile will probably have undergone considerable changes with irrigation when the area is leased for cultivation before afforestation. This fact should not be ignored when investigating problems of the suitability of soil for species and irrigation.

Reclamation of unsuitable soils.—The unsuitability of the soil may be due to (*i*) pan formation or (*ii*) high degree of salinity. The pan formation caused by dense clay very near the surface can be remedied by deep ploughing or deep soil working. Hard pan due to *kankar* is difficult to deal with unless it happens to be near the surface when the planting spots will be broken up. In the case of clay or *kankar* pan being low down, the remedy, as already stated, is to plant shallow rooted species and to water them sparingly. The pan due to concentration of injurious salts in the surface layer is dealt with below along with saline soils.

Saline or *kallar* soils may be divided into the following three main groups :—

(*i*) *Kallar soils*—soils having a high concentration of soluble salts, as shown by white or brown, loose incrustation on the surface,

(*ii*) *Rappar soils*—soils with a medium concentration of soluble salts, but very hard and impervious to water,

(*iii*) *Bara or bari soils*—soils containing a comparatively low concentration of soluble salts, but which have become very hard and impervious.

Kallar soils are known to improve with repeated watering which washes out or washes down the soluble salts. This improvement may also be due to small quantities of calcium salts brought in by canal water. The *bara* or *bari* soils have been reclaimed by treating them with calcium salts, such as calcium chloride and calcium sulphate (gypsum), followed by an average dose of farm-yard manure. This chemical treatment, if preceded by repeated watering, is said to be very effective.

Raising leguminous field crops, scraping away the salts, deep ploughing and manuring are a few other measures. The problem of the reclamation of saline soils in plantations, especially by chemical treatments, should better be investigated in collaboration with soil chemists of the agricultural and irrigation departments who are already working on the subject.

5. *Species problems.*—(*a*) *Choice of species for original stocking.*—In Changa Manga, several species were tried at first, but after numerous experiments, *shisham* (*Dalbergia sissoo*) was found to be the most suitable species for original stocking. Irrigated plantations in the Punjab, have, therefore, always been stocked with *shisham* in the first instance. The results have, however, not been uniformly successful everywhere. In plantations on the Lower Bari Doab Canal and the Sutlej valley project where there are great variations of soil, the climate is arid, rainfall not very deficient, but erratic in incidence, the subsoil water table low and the canal water supplies small and in some cases late, uncertain and irregular, *shisham,* though still the principal species, has failed to stock large areas. No systematic investigation has been carried out into the causes of failure or repeated dying back of *shisham* in the new plantations. Some believe it to be due to unsuitable soil conditions (high degree of salinity, stiff clay, coarse sand, etc.), others to excessive or deficient watering and still others to frost damage.

As regards soil conditions wherever *kallar* is present on the surface, or a layer of coarse sand or stiff clay exists on or immediately below it, the unsuitability of the soil for *shisham* becomes obvious. But there are areas which appear quite suitable for *shisham* but when shisham is actually planted on them, it refuses to grow. In the absence of any soil indicators (there is no vegetation on the ground at the time of stocking) and soil survey maps, it becomes difficult to distinguish one class of soil from another, and to say where to plant *shisham* and where *farash*, etc., at the time of first stocking. On such soils in Khanewal plantation, trial and error method is still being adopted, and either the whole area is first planted with *farash* or with three lines of *farash* alternating with three lines of *shisham*, and whatever species succeeds best, is selected for stocking the area next year. This practice is obviously no silviculture. It has, moreover, caused the invasion of coarse grasses in unsuccessful areas, and made the stocking in the following year difficult and expensive.

The species problems, therefore, are :—

(*i*) to find out the causes of the failure or repeated dying back of *shisham* in areas obviously suitable for it, and the remedial measures,

(*ii*) to find out one or more suitable substitutes for *shisham* in soils where it would not grow,

(*iii*) to find out where to grow *shisham* and where other species at the time of first stocking, *i.e.*, to distinguish *shisham* soils, *farash* soils, etc.

(*i*) The problem of the causes of failure or repeated dying back of *shisham* can best be investigated by digging pits, studying soil profiles and analysing soil samples from each horizon for pH values, concentration of injurious soluble salts, moisture contents etc. The soil study combined with the *shisham* root and shoot study, especially root response to soil stratification, will make it possible to find out definitely the cause of the failure or repeated dying back of *shisham* in these areas, and when the causes are known, remedial measures will suggest themselves—these lie in improvement of soil, regulation of water, cover crops or change of species. *Shisham* is believed to be a decidedly frost hardy species, and so its repeated dying back over large areas obviously suitable for it, will probably not be ascribed to frost in the first instance. But the damage is enormous and the phenomenon so like frost damage, that an immediate investigation into it is called for. The lines on which frost studies should be carried out require elucidation.

A number of species such as *farash* (*Tamarix articulata*). (*Acacia catechu*) *kikar* (*Acacia arabica*), *phulai* (*Acacia modesta*), *bakain* (*Melia azedarach*), *dhak* (*Butea frondosa*), *siris* (*Albizzia lebbek*), mulberry (*Morus alba*), *jand* (*Prosopis julifora* and *Prosopis spicigera*), *Acacia senegal* and *Eucalyptus* spp. have been tried from time to time, but all except *farash* have been discarded for original stocking for reasons of their susceptibility to frost or drought, slow growth and thorny nature. The principal species for original stocking in the irrigated plantations now are, (*i*) *shisham* and (*ii*) *farash*. *Farash*, which is an indigenous species, is being planted in areas that are obviously unsuitable for *shisham* and where *shisham* refuses to grow. But even this species has no where given full stocking, although hundreds of acres (more than 3,000 acres in one plantation alone !) have been planted up with it since 1928 : the results obtained are in no way commensurate with the labour, time and money spent and water used. This species seems to be quite suitable for saline soils in the plantations, but methods of its artificial regeneration, its exact soil and water requirements are still to be systematically studied and discussed ; the stocking so far done has been carried out entirely with shoot cuttings and the water given has been very excessive.

Jand (*Prosopis spicigera*) which is one of the most valuable indigenous species has probably not been given a fair trial. So is the case with *Prosopis juliflora*. *Salvadora oleoides* (*van*) which is another indigenous tree and which is generally found growing on *kallar* soils in dry rakhs, has not been tried at all—its firewood may not be much use, but there is a fair local demand for its timber. *Phulai* (*Acacia modesta*), though slow growing and thorny, is probably very suitable for shallow soils. These species including *farash* are essentially xerophytic in character.

Their water requirements are low and they are not very exacting as regards soil. They are, therefore, recommended for trial as substitutes for *shisham* in plantations with short water supplies and adverse climatic and edaphic conditions. The late leafing variety of *shisham* is also worth trial in plantations where canal water supply is late, *e.g.*, in plantations on the Sutlej valley project.

The area often is denuded of indigenous vegetation, when afforestation is taken up. There are, therefore, no soil or species indicators. The solution of this problem lies in soil survey and soil classification. As already stated under soil problems, a soil survey coupled with trials of the limited number of species fit for raising in irrigated plantations, will largely determine the suitability or unsuitability of each type of soil, for a particular species. A soil survey map will help in distinguishing soil types, and the species most suited to a type as found by experiment will be planted on it.

In cases where the plantation area remains under cultivation before afforestation, a continued close observation and record of the success or failure of field crops and reasons for the same, will greatly help in recognising good and bad soils at the time of afforestation. Water logged areas will be specially demarcated and plotted on soil survey maps, and species unsuited for such areas will not be planted on them.

With the formation of an irrigated plantation, the sparse original desert ground flora undergoes considerable changes. A number of new species invade the area, and form colonies, pure or in association with others. The study of ground vegetation and its correlation with successful and failed tree crops, if carried out on recognised principles of ecological studies, will materially help in the choice of species for different areas in the second rotation. Rarely recognisable soil and species indicators are easy to determine when a plantation has been formed, and this important study should not be neglected.

(*b*) *Choice of species for underplanting.*—*Shisham* is a light demander and has a tendency to form an open crop, with the result that the soil in older crops is often densely stocked with tall weeds and coarse grasses. It is, moreover, very liable to attacks by insects and fungi. *Farash* generally does not give a full stocking and forms a very open crop. Consequently *farash* areas are often a veritable sea of weeds and tall coarse grasses, impenetrable in the summer both for man and beast. In order to kill or keep down tall, coarse grasses, to protect soil and to mitigate the ravaging effects of insects and fungi, it is desirable to underplant both *shisham* and *farash* crops. The problem is what species to choose for this purpose and when to underplant them.

Mulberry and *bakain* (*Melia azedarach*) have been planted under open *shisham* crops, and it has been found that the best time to introduce them is immediately after first thinnings which are at present carried out at the age of six years. *Bakain* is now reproducing itself naturally in profusion wherever it has been introduced, coarse grasses have been killed or kept down and fine mixed crops of *shisham* and *bakain* have been obtained.

The success of mulberry as a timber tree is yet doubtful in new plantations in the arid region, but its underplanting is still going on, as it will at least keep the grasses and weeds down and thus protect the soil.

Experiments are now in progress with other species such as *Maclura aurantiaca* (osage orange), *Rhus viminalis, Rhus lancea, Acacia farnesiana, Prosopis juliflora, Schinus terebinthifolius*, etc., with the main object of keeping raw weeds and tall grasses down and to see if they would spread in areas now colonised by tall grasses such as *Eragrostis cynosuroides* (*dab*) and *Panicum antidotale* (*gharam*).

Both mulberry and *bakain* have also been planted under open *farash* crops experimentally, and it is still to be seen if one or both would succeed equally well in *farash* areas to fulfil the objects in view. The problem becomes fairly simple once it is known what species should be tried for underplanting.

6. *Irrigation problems.*—All species have different water requirements, both as regards total quantity and periodic application. These requirements, moreover, differ with the nature of the soil, length of growing season and the period of most active growth. The following are the special irrigation problems in the plantations requiring investigation :—

(*i*) The optimum water requirements of the principal plantation species on different types of soil, *i.e.*, the optimum delta required during an irrigation season (1st April to 15th October).

(*ii*) The best method of delivering it, *i.e.*, in 3 in., 6 in., 9 in., or 12 in. deep trenches.

(*iii*) The optimum number of irrigations required during the season, and its distribution over each month or period, *i.e.*, before rains, during rains and after rains.

(*iv*) The interval between two irrigations in each month or period.

(*v*) Cultural operations to economise in the use of water.

As already stated above, soil is a more potent factor than water in irrigated plantations, and therefore in the investigation of all irrigation problems, soil factors must be eliminated. This should not be difficult if a careful soil sampling is done, and definite soil types are taken up for each study. Plots of adequate size will not, of course, be easily available, but this must be sacrificed under peculiar conditions, in order to obtain fairly reliable results.

Trained staff for research work and sensitive instruments for measurement of water delivered, etc., are not available in the plantations, nor are suitable plots of adequate size met with on account of great variations of soil and crop. The usual research methods of lay out suitable for ordinary investigations, are therefore not desirable for the investigation of irrigation problems. It is consequently proposed that (*i*) instead of laying out experiments in randomised blocks or arranging them together in Latin square chess board, independent experiments for each factor to be studied should be laid out, and for comparison a larger number of repetitions used, (*ii*) basis of assessment should not be volume production, but height (which is a more sensitive measure) and mortality per cent. including replacements, (*iii*) the number of trees to be measured for assessment should be reduced to the minimum possible consistent with the accuracy desired, and (*iv*) in order to avoid marginal effects, trees growing along *khals* should be excluded from measurement.

The field experiments on water requirements of species should be preceded by or supplemented with nursery and pot experiments. Phenological studies on species under experiment should be carried out to determine the most active period or periods of growth. In order to find out the distribution of water in different soils in trench irrigation, the width and depth of percolation cones or trapezoids should be studied, and with it should be combined studies on root development of various species.

Cultural operations.—No cultural operations are usually carried out in irrigated plantations except weeding (which does not include soil working) and *kana* stubbing. As a result of repeated watering, the soil is caked hard resulting in more loss of water by evaporation which affects the growth adversely. In arid countries, dry farming methods of cultivation are employed to effect economy in the use of water. In the irrigated plantations also, periodic loosening of the surface soil by ploughing or otherwise, especially in stiff clay soils, will prove beneficial—it will aerate the soil, prevent waste of water by evaporation and thereby better growth will be obtained with less water. Periodic soil working is especially indicated in plantations on the Sutlej valley project where water shortage is keenly felt. The method is at least worth trial.

7. *Miscellaneous problems.*—Planting espacement experiments with *shisham* cuttings are going on in Chichawatni since 1928, with the object of finding out the optimum spacing for planting in irrigated plantations. The lay out of the investigation is in accordance with the usually accepted research methods. The assessment methods and the life of the investigation are, however, still undecided. After first thinnings in plots with closer spacing of planting, the spacing becomes about the same in all plots, and it is questionable if there is really need for carrying on the investigation till the rotation age or to base it on final or total yield. The immediate object is to see what spacing gives close canopy at the earliest time, consistent of course with normal development of trees. The investigation should therefore really cease when this object is served. In addition to usual measurements of the standing crop, measurement of crown width and length of a few sample trees in plots of all spacing should also be carried out at the time of each thinning.

8. *Conclusion.*—The formation of irrigated plantations is a work of highly specialised nature. Its problems are varied and unique, and as they bear mostly on soil and irrigation, their successful investigation not only requires a full knowledge of the plantation species and research methods, but also a knowledge of soil science, irrigation technique and allied sciences. It is, therefore, recommended that methods of the investigation of irrigated plantation problems be scrutinized by the Central Silviculturist and incorporated in the Experimental Research Manual after discussing them with soil and irrigation experts, if and where necessary.

References.

(1) Silviculture of Indian Trees, Volume I.—*R. S. Troup.*

(2) Punjab Irrigated Plantations Manual.—*Bahadur Singh.*

(3) Silviculture Research Manual, Volume I.—*H. G. Champion.*

(4) Imperial Bureau of Soil Science, Technical Communication No. 15.

(5) Principles of Irrigation Practice.—*Widstoe.*

(6) Punjab Forest Conference Proceedings, 1930 and 1931.

(7) Bari Soil Reclamation at Montgomery (Tribune dated 26th August 1934).—*Dalip Singh.*

Note on preceding paper by R. P. Dalley, Divisional Forest Officer, Hyderabad (Sind).

Mr. Suri's note will be of great assistance to us in Sind especially as it emphasises and need for research in connection with soils, species and irrigation. The Sind Agricultural Department and the P. W. D. here are doing a great deal of research work that will be of assistance to us in our problems, but we shall have to do a great deal ourselves if we are to succeed in establishing irrigated plantations. The Punjab Forest Department has set us a good example and is very generously doing what it can to help Sind in this connection. A visit to the Punjab Plantations is an inspiration and the best argument in favour of the value of such plantations, for they demonstrate how the silvicultural problems connected with such plantations should be tackled.

2. Although Sind conditions may in many respects be similar to those of the Punjab they are nevertheless different in many ways and are probably more favourable from a financial point of view. We are situated nearer Karachi and most of our forests are well served by the Railway. From a silvicultural point of view, too, our conditions are probably more favourable—a higher subsoil water level, a somewhat milder climate and the fact that our areas already exist as forests, and have some tree growth on them. In view of the fact, however, that the Inspector-General of Forests and a Committee of Punjab and

Sind Forest Officers will shortly examine all these questions there is no point in my attempting to make general observations of the above nature. I merely wish to suggest that, as Mr. Suri's Note is going to be discussed at the Silvicultural Conference, information regarding financial results achieved in the Punjab plantations should also be put before the Conference. This factor more than any other will determine whether an irrigated plantation is to be started or not. In other words to what extent will the success of the plantation depend on—

(*a*) the production of timber.

(*b*) the production of fuel.

If, as may be the case, the Punjab forests are likely in the future to be able to meet the demand for mulberry for sports goods, it is no use Sind reckoning on getting a good return from that source. On the contrary Sind ought I think to co-operate with the Punjab by ensuring that the Punjab market is not flooded with more mulberry than can be absorbed at a good price. With regard to *shisham*, too, we ought to know what the future demand for *shisham* timber is likely to be. It would be safe of course to calculate only on a fuel basis for the future.

3. One of the things that impressed me when I paid a flying visit to the Chhanga Manga and Chichawatni plantations last year was that they were chiefly providing fire wood (hardly any charcoal) and that this firewood was being railed to distant parts of the Punjab. For instance firewood was even being sent to Abbottabad (where forests exist) from Chhanga Manga. The reason was that concentrated working in the immediate vicinity of a Railway Station was a very important factor in connection with the disposal of firewood. Here material was always available in any desired form and could be loaded and despatched without any trouble to the purchaser at a price which could be calculated with exactness.

4. In Lower Sind our two principal fuel species are *Acacia arabica* and *Prosopis spicigera*. These are complementary in regard to their silvicultural characteristics. The former is shallow-rooted, frost tender and requires a good soil. The latter is very deep-rooted is frost hardy and succeeds on poor soils. The former needs a good water supply the latter very little. By sticking to these two species we are fairly certain of making a success of irrigated plantations if our object is to produce charcoal only. Experiments are being tried with other species. Of these, *Acacia catechu* and *Hardwickia binata* are promising in the nursery stage.

5. One of the questions that must engage our attention is the extent to which "surplus" water can be used to keep down costs. The P. W. D. will gladly give us "surplus" water free of cost at times when it is not required for field crops. If we can arrange to have "assured" water only for such time as is necessary to establish our crops and can make the older crops depend on surplus and sub-soil water our plantation costs will be greatly reduced.

Report of Debate.

Mr. Mobbs.—This is a special subject, concerning I think chiefly the Punjab. So far as I am aware, no papers have been submitted on the subject for this conference, and as a U. P. man I am not really competent to initiate a discussion.

In the United Provinces very few irrigated plantations have been raised at all. Irrigation was started in very frosty places called *chandars*, in which there are masses of *sal* regeneration which is annually killed back by frost. When the Sarda canal was constructed, it was thought that irrigation might reduce the frost damage and that the *sal* might be made to grow up, while alternatively it might be possible to raise a nurse crop of more frost hardy species under which the *sal* might develop.

Some success was achieved, particularly in raising *sissu* as a nurse crop, but the experiments were ultimately abandoned owing to the unreliability of the water supply, and also I think partly owing to the cost of the work. Water was sometimes not available in the cold weather just when it was most required, and at the critical moment frost came in and destroyed much of past good work. Messrs. *Champion* and *Garland* also spoke.

ITEM 6 (*f*).

Record of expenditure on experiments.

Notes were received from Bengal, Madras, Bombay, Assam and Bihar and Orissa among which those from Bengal and Madras include definite procedures for consideration and so were circulated (*cf. infra*) before the Conference. Mr. Mobbs (United Provinces) opened the debate with a survey of the subject explaining the procedure followed in the United Provinces. A brief discussion (p. 110) followed in which several delegates took part. The following resolution was proposed by Mr. E. A. Smythies, seconded by Mr. C. K. Homfray and passed by the Conference.

RESOLUTION ON ITEM 6 (*f*).

Resolved that—

This Conference considers that records of expenditure on experiments should invariably be maintained for Stage II experiments, but that records of cost should only be maintained for Stage I experiments if considered feasible and useful.

Further, that no standard forms can be laid down for records of expenditure, and forms must be divised according to local conditions.

Summary Note.

Circulated by the Silviculturist, Forest Research Institute.

It is to be considered whether it is advisable to include in the *Experimental* ***Manual*** **a recommendation that such a record should be maintained and if so** whether a standard form should be added or the form be left for decision for each instance on individual requirements.

A. *Note from Silviculturist, Madras.*—The following form of cost statement is generally adopted in Experimental Plot files, the headings being modified according to the nature of the experiment.

Experimental Plot No. 112. *Nilambur Division.*

Record of cost.

Month.	Details of costs.								Remarks.
	Pitting.	Planting.	Replacement of casualties.	Weeding.	Soil aeration.	Enumeration.	Demarcation.	Running total.	
June 1931 ..	17 8 0	4 0 0	..	..	..	..	..	21 8 0	
July ..	..	..	4 0 0	..	..	..	..	25 8 0	
August ..	..	..	1 14 0	21 4 0	..	..	..	48 10 0	

Note.—Headings are entered as required according to the nature of the experiment.

B. *Note from Silviculturist, Bengal.*—The form submitted below is used in Bengal to record expenditure incurred on all Sample Plots, Diameter Increment Plots, Experimental and Garden Plots, etc., and is kept at the back of each file. As regards recording expenditure on scientific plots (Sample Plots, Diameter Increment plots), this may not be considered by some to be necessary, but in practice it has been found to be extremely useful in checking and comparing expenditure and seeing exactly how money is being spent. For experimental work a form for recording expenditure is essential as the success of most experimental work usually depends on whether it is financially possible or not. In the past such expenditure was all mixed up with observations etc., and took much time to extract and some such form should and printed. The one important point to remember is that entries in should always keep separate, expenditure which would ordinarily be in divisional work and that which is purely research detail. Thus instead of writing " cleaning and enumerating of seedlings Rs. 5 "—there should be separate entries for the cleaning which would be necessary in any case and enumerating which is purely a research item. Again " Renewing of boundary pillars and climber cutting " should not be entered as one item but the two operations and their costs entered separately. If these items are not kept separate it would not be possible to give figures of the cost that would ordinarily be incurred by a division if the treatment, was standardised. Purely research items are underlined in red ink so as they are easily distingushable. If desired, an abstract of expenditure on the cultural operations only can be made at the end of the year and carried forward to show the progressive expenditure at a place as illustrated below—

Financial year.	Amount.			Total to date.		
	Rs.	A.	P.	Rs.	A.	P.
1928-29	13	8	0	13	8	0
1929-30	7	6	0	20	14	0
1930-31	5	3	0	26	1	0
1931-32	4	1	0	30	2	0
1932-33	2	13	0	32	15	0

E. P. No. 9-A of Kurseong Division for experiments relating to the cost of climber cutting.

Voucher No. and date.	Particulars of work done.	Amount.			Remarks.
		Rs.	A.	P.	
N/5 of April 1932 ..	*Laying out digging trenches and putting corner posts.*	*1*	*8*	*0*	
N/8 of June 1932 ..	Climber cutting	0	14	0	
N/9 of June 1932 ..	*Enumeration of climbers*	*0*	*4*	*0*	
S/4 of July 1932 ..	Cleaning sal lines	2	4	0	Extract from range cash book.
N/16 of August 1932 ..	Cleaning sal lines	2	4	0	
N/10 of October 1932 ..	Climber cutting	0	10	0	
N/11 of October 1932 ..	*Enumeration of climbers*	*0*	*4*	*0*	
N/4 of May 1933 ..	Cleaning of sal lines	1	8	0	
N/8 of July 1933 ..	Climber cutting	0	8	0	
N/9 of July 1933 ..	*Enumeration of climbers*	*0*	*4*	*0*	
N/12 of September 1933..	Cleaning sal lines	1	4	0	
N/13 of March 1934 ..	*Redigging boundary trenches and repainting boards and posts.*	*1*	*0*	*0*	
N/14 of June 1934 ..	Cleaning sal lines	1	8	0	
N/4 of July 1934 ..	Climber cutting	0	8	0	
N/5 of July 1934 ..	*Enumeration of climbers*	*0*	*4*	*0*	

Note.—Items italicised refer to Research expenditure only.

Report of Debate.

Mr. Mobbs.—There are two questions before the conference :—

(*a*) Should we recommend that records of expenditure be maintained on experimental works, and if so whether on all experiments or only on some ; and

(*b*) If we do recommend the maintenance of records of expenditure, should we try to devise a standard form or forms to ensure a measure of comparability between the provinces, or should we leave the matter of forms to be decided for each experiment on its individual requirements.

Bengal and Madras have put up cases for the maintenance of such records and have submitted forms which are in actual use by them. These appear quite simple, provided expenditure on the various works can be properly classified.

Fairly detailed records are kept in the United Provinces for purposes of get check, but if we were to attempt to maintain records in the way Bengal and Madras do, we should find it extremely difficult to separate expenditure on purely research operations from expenditure that would normally be incurred in divisional work. There are several reasons for this, which doubtless other provinces would also experience. The most important in the case of the U. P. are :—

(1) Frequently experiments are adjacent and work is done in them simultaneously by the same gang of coolies. If the work is being done directly under the supervision of the Silvicultural staff, it would be possible to separate expenditure in the various experiments and to classify it for each under the heads " research " and " divisional ". But frequently work is done for us by the territorial divisional staff, and when they employ one gang of coolies for simultaneous work in two or three experiments, it would be very difficult for them to classify the expenditure in the way we would require. For this reason, in my budget and expenditure records, I often group two or three experiments together under one amount.

(2) Then there is the difficulty of differentiating between divisional work and purely experimental work. For instance, in our *sal* artificial regeneration experiment in Haldwani division we have 8 plots under different conditions of treatment. Weedings have to be done in the lines in each plot, and at the same time the plot lines separating the plots and the boundary lines round the whole experiment have to be kept cleared. One gang of coolies obviously does all the weeding and clearing work together, and to separate the cost of weeding the lines of seedlings, which a territorial division would have to do, from the cost of clearing all the plot lines, which are really purely experimental, as a division would not have to do this work, is impracticable.

(3) A further point is in connection with the number of subplots and the variety of conditions. For instance, in our *sal* natural regeneration experiments, we have a dozen or more plots under different conditions of fencing, burning, shrub cutting, etc., in each experiment. For detailed records of expenditure to be of any use, we must know the expenditure by plots, since the answer of the experiments will, we hope, be that the treatment in some plots is better than that for other plots, and a single record of expenditure for the whole experiment would not be of much use. Again as most of the work, such as burning and shrub cutting, is done by the territorial staff, and as it is usually done in several plots at the same time, I think it would be impossible to get the expenditure classified according to the intensity and amount of work in each plot, even if the expenditure on the experiment as a whole were known and it could be classified under the heads " divisional " and " research ".

It seems obvious therefore, that in some straightforward cases, such as the establishment of a plantation under one set of conditions, or the study of the effect of climber cutting or weeding on increments, a record of expenditure would be comparatively simple and would probably be useful. But in many other cases any attempt to compile a useful record of expenditure would be very difficult and would involve much labour in differentiating costs in subplots with different methods of treatment. We certainly could not devise a standard form to cover all cases.

Item 6 (f).]

To go deeper still, the question arises as to whether we can ever really compare expenditure on primary experiments with probable expenditure if works are undertaken on a large scale, and if this is not possible then a detailed record of expenditure on experiments classified under the heads "divisional" and "research" may not only be of little practical use, but may actually be misleading.

In the United Provinces we recognise that expenditure on experimental research must always be greater, even for the same operations, than in divisional work. There are several reasons for this :—

(*i*) We are initiating work, and consequently usually have to spend more than when a work is a routine matter.

(*ii*) Small operations always cost more than the same operations on a large scale.

(*iii*) With our limited staff and to satisfy the conditions of the experiments, we frequently have to get work done at once. This usually means the impossibility of arranging labour beforehand, and the result is that when we suddenly demand labour, we have to pay higher rates than normal for it. Also, when our works are not very extensive, we often have to pay a full day's wages for only half a day's work.

Realising this, in the U. P. we distinguish between the two stages of experiments—

Stage I—purely experimental.

Stage II—application of experimental results on a larger scale to test practicability.

In Stage I experiments we are out to obtain definite silvicultural information without particular regard to cost. In Stage II experiments we are working with the definite object of applying silvicultural information to practical conditions. Everything depends on the cost, and the Stage II experiments are carried out on a large enough scale to make costs comparable with what they would be in large scale divisional work. Consequently records of expenditure are needed, and it is laid down that they must be maintained. Apart from standard plantation forms, no standard forms for record of expenditure have been laid down, and they are devised according to the needs of each experiment.

This system seems to me essentially logical and reasonable, and I suggest that it be adopted by all provinces, although there is no reason why those who want to should not maintain more detailed records for Stage I experiments.

I therefore suggest that the conference pass the following resolution :—

This conference considers that records of expenditure on experiments should invariably be maintained for Stage II experiments, but that records of cost should only be maintained for Stage I experiments if feasible and considered useful.

Further, that no standard forms can be laid down for records of expenditure, and forms must be devised according to local conditions.

* * * * * *

Mr. Howard : The real trouble in the matter as far as we are concerned is that we have found that there is a definite difference between what you do for a quarter of an acre and for 25 acres. Stage II is a repetition in theory of Stage I. Now in Stage I we definitely do not want to show the expenditure. We know perfectly well it is costing far more than it should. On the other hand the moment we have got the silvicultural solution, and repeat the experiment in Stage II, then we are perfectly prepared for anybody to criticise the figures of cost because we know it is being done on an economic scale.

Mr. Homfray : We do not distinguish between Stages I and II. We always keep at the end of our file a simple record of expenditure and I personally have found no difficulty in separating the cost of the different operations. We always have some subordinate on the job who keeps this record.

Although research experiments are bound to be expensive, I feel we want to know exactly how our money is going so that we can point out in what places it may be possible to reduce expenditure when large scale work is undertaken.

Mr Laurie : In Madras we have been differentiating between Stage I and Stage II experiments as laid down in the *Manual.* For Stage I no record of costs is kept—the whole garden is covered by a single estimate. In Stage I (*b*) the experiment is usually done on a quarter to half an acre scale and we keep a record of costs on our files. I do not know that they have ever been referred to, or that they are very useful. Stage II experiments are always done by the division. We have very few of them actually because most divisions have accepted the results of Stage I experiments on their silvicultural value only.

Mr. Osmaston : Our experiments are as in Madras, small scale experiments. I do not think it is necessary to keep special forms.

Mr. Howard : Let us hear what a Conservator has to say, who has to deal with these money problems.

Mr. Shebbeare : The experiments referred to by Mr. Homfray are done in plantations, and all the items are recorded in any case. It is easy to see which of them concern the silviculturist only. Every penny spent on the plantation is spent by the Ranger, therefore he has got to have it written in his book. If you do not want the Silviculturist to keep records he need not do so, but you cannot tell the Ranger not to enter up what is his work.

Mr. Howard : I think we all want to check but the point is we do not want to have a record which anybody else may see.

Mr. Watts : We do not maintain any records of costs in the Central Provinces. We do not think there is any advantage in doing so. Generally I get the territorial Ranger to pay for the work and he does not even tell me how he spent the money.

Mr. Mobbs : I think it is quite obvious that the problems are different in different provinces and I think we should confirm that for Stage II experiments. records of costs must be maintained and that we leave it entirely to the provinces as regards Stage I experiments.

ITEM 6 (*g*).

Statistical Analysis.

Two addenda to Section XVII of the *Experimental Manual* were proposed by Mr. Mahendru (Punjab) for the analysis of the data obtained in germination tests and similar investigations, and of data arranged in groups. These were considered by the Committee on Item 6 and accepted.

The Silviculturist, Forest Research Institute, reported that he considered that much further study was needed of the statistical aspects of working with small samples, and that he was in correspondence with statistical authorities on the point. Mr. Laurie (Madras) pointed out that abnormal distribution series were frequently encountered in silvicultural research data, and this point should also be further investigated. He also drew attention to shortened methods for computing Standard Errors and recommended their inclusion in the *Manual*

Mr. Chaturvedi (United Provinces) referred to the solution sometimes applicable to the difficulty in finding initially comparable plots for co-operative investigations, *viz.*, the determination of the constancy of their difference during a period of observation prior to the introduction of the variable to be studied. Mr. Champion pointed out that unfortunately this was very frequently impossible, as with age at first thinning.

These proposals were all recommended for inclusion in the *Experimental Manual* in the general report of the Committee on Item 6 which was accepted by the Conference (*cf.* p. 63).

* * * * * * * *

Proposal by Mr. Mahendru.

Formula for the determination of the mean and its S. D. when data are arranged in groups.

[*Addendum to Experimental Manual, p. 60.*]

Method 4.—Let f_1, f_2, f_3, f_4, f_5,................be group frequencies and i the group interval. Then to find out the mean and S. E. proceed as follow :—

1. Select any group preferably with maximum frequency which will be taken as the arbitrary mean and enter the distance of each group from this mean in arbitrary units—the group to the right to be considered positive and to the left as negative.

2. Multiply each frequency with the rank number and find the algebraic sum having due regard to sign. Divide this quantity so obtained by the sum of frequency and multiply by the interval of classification (i). The resulting value added to the arbitrary mean, with due allowance for sign, gives the true mean.

3. Multiply again the product values for each group in step 1 by the rank number and add up. Divide the sum by the total frequencies and subtract the square of value of correction for true mean (before multiplying by i). The square root multiplied by i will give S. D., and S. D. divided by square root of frequency total will give S. E.

Example.

f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8
$-3f_1$	$-2f_2$	$-f_3$	—	$+f_5$	$+2f_6$	$+3f_7$	$+4f_8$
$+9f_1$	$+4f_2$	$+f_3$	—	$+f_5$	$+4f_6$	$+9f_7$	$+16f_8$

(*i*) Let f_4 be the maximum frequency, and so this group is selected as giving the arbitrary mean.

(*ii*) $f_1+f_2+f_3+f_4+f_5+f_6+f_7+f_8=N$

(*iii*) $(-3f_1-2f_2-f_3)+(f_5+2f_6+\ldots\ldots\ldots)=A$

(*iv*) $\frac{A}{N}=$ Correction for true mean.

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$$\text{True mean} = X \pm \frac{A}{N} \times i$$

$$(v) = 9f_1 + 4f_2 + f_3 + f_5 + \ldots\ldots\ldots\ldots\ldots = S$$

$$\text{S.D.} = i \times \sqrt{\frac{S}{N} - \left(\frac{A}{N}\right)^2}$$

$$\text{S.E.} = \frac{\text{S. D.}}{\sqrt{N}}$$

Example.

To find the mean height for the following seedlings grouped in 6″ height classes.

No. of seedlings in different classes.

6″	12″	18″	24″	30″	36″	42″	48″	54″	60″	
625	480	210	540	370	250	100	75	50	20	——A.
—3	—2	—1	..	1	2	3	4	5	6	
—1875	—960	—210	..	+370	+500	+300	+300	+250	+120	——B.
5625	1920	210	..	370	1000	900	1200	1250	720	——C.

Total of frequencies (Line A) .. = 2720

Algebraic sum of values in line B .. = —1205

Mean height .. .. .. $= 24'' - \frac{1205}{2720} \times 6''$ (frequency interval) $= 24'' - \cdot 44 \times 6'' = 21 \cdot 4''$

Total of values in line C .. .. = 13195

$$\text{S. D.} = \sqrt{\frac{13195}{2720} - (\cdot 44)^2} \times 6 = \pm\ 12 \cdot 6$$

$$\text{S. E.} = \frac{12 \cdot 6}{\sqrt{2720}} = \pm\ 0 \cdot 24$$

* * * * * * * * * * *

[Item 6 (g).

Addendum to Experimental Manual, p. 63.

Ex. (*b*). To compare two germination tests done with n_1 and n_2 seeds in order to determine if they are significantly different :—

Let proportion of 1st. germination be P_1, and proportion of 2nd. germination be P_2.

Then error of $P_1 = \sqrt{\frac{P_1 - P_1^2}{n_1}}$

$P_2 = \sqrt{\frac{P_2 - P_2^2}{n_2}}$

Error of difference $= \sqrt{\frac{P_1 - P_1^2}{n_1} + \frac{P_2 - P_2^2}{n_2}} = E$

Difference between P_1 and $P_2 = d$

d must be at least 2 times E if the results are to be considered as mathematically significant.

Example.

$P_1 = \cdot 55$ (Stored in sealed tins).

$P_2 = \cdot 36$ (Stored in cloth bags).

$n_1 = 100$, $n_2 = 100$

Error of $P_1 = \sqrt{\frac{\cdot 55 - (\cdot 55)^2}{100}}$

Error of $P_2 = \sqrt{\frac{\cdot 36 - (\cdot 36)^2}{100}}$

$$E = \sqrt{\frac{\cdot 55 - (\cdot 55)^2}{100} + \frac{\cdot 36 - \cdot(36)^2}{100}}$$

$$= \sqrt{\cdot 002475 + \cdot 002304}$$

$$= \sqrt{\cdot 004779}$$

$$= \cdot 069$$

Difference between P_1 and $P_2 = d = \cdot 55 - \cdot 36 = \cdot 19$

$d = \cdot 19$ is more than 2 times E ($\cdot 069$)

so mathematically there is significant difference between two germinations

ITEM 7.

Importance of seed origin.

Several provinces reported the results obtained in the all-India teak seed origin investigation, and a summary was compiled at the Research Institute and read by the Silviculturist in opening the brief debate.

The following resolution was proposed by Mr. Champion, seconded by Mr. Mooney (Bihar and Orissa) and passed by the Conference.

RESOLUTION ON ITEM 7.

Resolved that—

This Conference is of opinion that the investigation in progress for teak will meet present requirements in this field provided it is completed according to plan. The later maintenance of the existing plots must be standardised.

Where any need for similar investigation on other species is felt, a co-operative investigation should be made on the lines which have been found satisfactory for teak.

Report of the Silviculturist, Forest Research Institute, on action taken on the Resolution passed by the 1929 Conference.

The resolution was as follows :—Resolved that the Central Silviculturist should prepare an abstract of the latest European experience on the influence of seed (seed-bearer and locality) on the plants produced. He should suggest lines of research in collaboration with Provincial Silviculturists.

The required summary of information to date was published by the Central Silviculturist as *Indian Forest Records*, Vol. XVII, Pt. V, 1933. A co-operative experiment on the influence of seed origin of teak was organised by the Central Silviculturist with the collaboration of all teak growing provinces. Investigations are in progress with a total of 11 seed origins in 12 different centres in Burma (2), Madras (2), Central Provinces (2), United Provinces (1), Bengal (1), Mysore (2), Travancore (1), Forest Research Institute (11), and despite many initial difficulties, interesting preliminary results have been obtained (*cf. infra*). There are also various other experiments on the subject with teak and other species at the Forest Research Institute and in several provinces.

Summary of Reports on the All-India Teak Seed Origin Investigation.

Seed weight.—The Burma seed was the heaviest (510 per lb.) and Kanara, Bombay, ,the lightest (1,200 per lb.) ; Betul (C. P.) and Jhansi (U. P.) seeds were also light (1,000—1,064 to the lb.). Other origins varied from 720 to 860 to the lb. These figures were collected at the Forest Research Institute, and are averages for the 1931-33 consignments (See Table 1).

Mysore similarly found the seed from South Burma to be heaviest and the Kanara (Bombay), the lightest.

Seed size.—Burma seed was the biggest (0.61″ in diameter) and Kanara (Bombay) the smallest (0.44″ in diameter). Others varied from 0.45″ to 0.55″ in diameter. (Forest Research Institute data, see Table 1).

Germination capacity.—South Burma (Tharrawaddy) seed gave the best results in 1932 and 1933 at the F. R. I. as well in Bengal and Burma. In 1931 it had practically failed to germinate at all centres. Nilambur seed gave very satisfactory results at the F. R. I., in Bengal and in Burma.

Seeds from the dry localities, *viz.*, Betul, (C. P.), Jhansi (U. P.) and Khandesh (Bombay) gave poor germination ; Kanara (Bombay) seed also gave poor results. Other origins were satisfactory. (See Table 1).

Growth.—It has been noted so far that generally the local seed does better than imported stock, but exceptions to this are reported from the C. P. The following origins gave satisfactory results in all places :—Burma, Madras, Travancore, and Mysore. Seeds from the dry localities did not do so well (Khandesh, Betul, except at Jhansi, U. P.). Average heights are tabulated in Tables 2 and 2*a* and survival percent after 2 or 3 seasons in Table 3.

Morphological differences between origins in colour, shape and texture of the leaves, length of petiole and tomentum on the stem are marked, the Burma origins being particularly easily recognised. The following note has been written by the Forest Botanist on the Research Institute plants and a note from Madras is also appended.—*P. N. Deogun.*

Burma North and South.—These can usually be distinguished at sight by their large leaves, stout tomentose stems and the frequent frilling of the base of the blade near the potiole. No reliable feature could be found to separate the North Burma plant from the South Burma one.

Nilambur.—Much like the Burmese plants and with leaves almost as large and larger than those of any Indian form. This can usually be distinguished by the very conspicuous frilling of the leaf bases. Unlike the Burmese plants the stems are comparatively glabrous.

Mysore moist.—The best feature I find for distinguishing this form is the comparatively long petiole of the leaf. The stems are pale tomentose though this is not a reliable character and vigorous plants somewhat resemble those of Nilambur.

Madras intermediate, Travancore and Mysore dry.—Not as vigorous as the Nilambur plants and only distinguishable from the Mysore moist type by the shorter petioles. I cannot find any character by which to distinguish the three from one another.

Central Provinces.—This, to me, appears to have the smallest leaves of all and perhaps the most harsh.

The shape of the leaf is very variable and I could find no good character here to distinguish the various origins. In small plants the leaves are generally narrower and more gradually tapering to the base than in the more vigorous larger plants on which the leaves were comparatively much broader and abruptly narrowed and frequently frilled near the base.—*C. E. Parkinson.*

TABLE 1.

Origin of seed.			Av. diam. of seed in inches.	Av. number of seed per lb.		Av. germination per cent.			Plant per cent. Kakankoti.
Province.		Locality.		Kakankoti.	F.R.I.	F.R.I.	Bengal.	Burma.	
Burma	North ..	Myitkyina ..	·62	705	542	35	17	7	2·6
	South ..	Tharrawaddy ..	·59	483	484	52	60	23	0·1
Madras		Nilambur ..	·54	885	773	34	25	29	11·2
		Walayar	·55	645	722	38	..	..	16·6
Central Provinces ..		Betul	·45	..	999	12	..	..	..
United Provinces ..		Jhansi	·48	..	1064	8	..	..	..
Bombay	North ..	Khandesh ..	·45	..	763	9	10	3	..
	South ..	Kanara ..	·44	1120	1200	13	22	8	1·2
Travancore ..		Koni	·52	..	863	38	..	19	..
Mysore		Kakankoti ..	·48	806	863	46	..	7	20·5
		Shimoga	·47	884	830	26	..	..	2·4
Bengal		Kaptai	..	..	..	..	60	..	..

TABLE 2.

All-India Teak Experiment—Average height in feet.

Locality of Investigation.		Origin of Seed.													
		Burma.		Madras.		C.P.	U.P.	Bombay		Travancore.	Mysore.		
		North (Myitkyna).	South (Tharrawaddy).	Nilambur.	Walayar.	Betul.	Jhansi.	Khandesh and Deomogra.	Kanara.	Koni.	Kakankoti.	Shimoga.	Season.
Burma ..	North Myitkyina ..	10·6	..	..	..	..	..	..	7·9	13·2	..	..	3
		10·5	10·4	..	..	..	..	8·5	10·4	12·1	..	..	3
	South Kunsan ..	9·6	12·3	12·6	..	..	..	..	8·8	11·0	..	..	3
		13·6	14·0	15·0	..	..	..	12·4	13·8	13·3	..	..	3
Madras ..	Nilambur ..	9·6	..	13·5	10·9	..	..	..	13·5	11·2	..	..	3
	Walayar ..	..	..	4·0	5·0	..	..	..	..	..	3·2	..	2
Central Provinces	On schist soil ..	9·5	..	18·0	..	6·0	..	..	11·0	..	17·0	..	3
	On gneiss soil ..	13·0	..	19·0	..	12·5	..	..	13·5	..	16·5	..	3
United Provinces	Gorakhpur ..	14·6	12·7	14·5	..	16·3	..	11·3	14·2	..	..	..	3
		10·8	..	12·3	..	8·9	..	8·4	10·4	..	..	..	..
	Haldwani ..	3·5	3·0	5·5	..	..	..	1·3	5·5	..	..	..	3
		1·5	1·5	1·9	..	..	..	0·8	1·8	..	..	..	..
Travancore	.. Koni ..	..	11·8	16·1	..	..	..	..	10·5	19·1	..	..	3
Mysore ..	Kakankoti ..	..	..	..	Not reported.			..	..	..	..	..	..
	Shimoga ..	..	..	..	Not reported.			..	..	..	..	..	..
Bengal	.. Kaptai ..	0·6	0·8	1·0	..	..	..	0·4	0·7	..	..	..	1
		0·6	0·7	0·8	..	..	..	0·3	0·3	..	..	..	1
F. R. I.	.. Dehra Dun ..	..	0·5	0·6	0·6	..	..	..	..	0·6	0·6	0·6	1

TABLE 2*a*.

The following table shows for each locality, the seed origin which has given the best average height growth of surviving plants.

Locality.	Seed origin giving best average height.	Second best.
Myitkyina, North Burma ..	Koni (Travancore) ..	Tharrawaddy and Nilambur.
Zigon, South Burma ..	Nilambur (Madras) ..	Tharrawaddy and Travancore.
Nilambur (Madras) ..	Kanara (Bombay) ..	Nilambur and Mount Stuart.
Mount Stuart (Madras) ..	Mount Stuart (Madras) ..	Nilambur.
Bilaspur (C. P.) ..	Nilambur (Madras) ..	Kakankoti.
Gorakhpur (U. P.) ..	Betul (C. P.)* ..	Kanara, Myitkyina, Nilambur.
Haldwani, (U. P.) ..	Nilambur (Madras) ..	Kanara (Betul not tried).
Koni (Travancore) ..	Koni ..	Nilambur.
Kakankoti (Mysore) ..	Kakankoti ..	Walayar.
Shimoga (Mysore) ..	Nilambur and Shimoga ..	....
Kaptai (Bengal) ..	Nilambur ..	Tharrawaddy, Kaptai.
F. R. I. ..	Burma origins ..	....

* Very few surviving plants.

TABLE 3.

All-India Teak Experiment—Survival per cent.

Locality of Investigation.		Origin of seed.											No. of Seasons.
		Burma.		Madras.		C. P.	U. P.	Bombay.		Travancore.	Mysore.		
		North, Myitkyina.	South, Tharrawaddy and Zigon.	Nilambur.	Walayar.	Betul.	Jhansi.	North Khandesh and Deomogra.	Kanara.	Koni.	Kakan koti.	Shimoga.	
Burma North ..	Myitkyina ..	78	..	..	..	..	..	..	46	73	..	..	3
		85	74	..	..	..	..	58	77	87	..	..	3
Burma South ..	Kunsan ..	89	88	88	..	..	..	..	86	78	..	..	3
		78	83	85	..	..	..	74	72	86	..	..	3
Madras ..	Nilambur ..	44	..	96	86	..	..	..	88	96	..	..	3
	Walayar ..	..	..	74	83	..	..	..	..	..	62	..	2
Central Provinces	On schist soil ..	98	..	99	..	96	..	..	99	..	98	..	3
	On gneiss soil ..	100	..	97	..	99	..	..	99	..	98	..	3
United Provinces	Gorakhpur ..	100	100	100	..	98	..	100	100	..	..	..	..
		83	..	89	..	93	..	98	99	..	..	..	..
	Haldwani ..	98	92	99	..	..	..	91	98	..	..	..	..
		61	78	68	..	..	..	63	77	..	..	..	..
Travancore ..	Koni ..	..	95	77	..	..	..	..	11	78	..	..	3
Mysore ..	Kakankoti ..	..	..	..	..	..	..	..	..	..	..	..	..
	Shimoga* ..	..	..	45	..	..	..	37	..	..	66	57	3
		..	..	81	..	..	..	36	..	..	49	57	3
Bengal	Kaptai	80	99	97	..	..	..	97	91	..	..	..	1
		93	92	93	..	..	..	91	86	..	..	..	1
F. R. I. ..	Dehra Dun ..	99	95	97	94	94	99	100	96	93	98	98	1
		..	82	95	100	..	..	..	..	100	94	99	1

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* Tried at two places—Large replacements in the third year in Nilambur, Bombay and local in one place, and in Bombay in the other.

Madras note on Botanical differences.

Tomentum on young shoots and leaves.—Nilambur, Travancore and Mount Stuart have white tomentum on young stems and creamy white tomentum on young leaves.

Burma origins have a brownish tomentum, more closely appressed on the South Burma origin than on the North ones.

South Bombay has a very distinctive light golden tomentum, dense and closely appressed. The underside of very young leaves is bright golden in colour.

Texture of leaves.—In Bombay and Burma origins the upper side of leaves is rougher than the South India origin.

Shape of leaves.—Burma origins are more rounded in shape than others. Travancore and South Bombay origins are least rounded in shape.—*M. V. Laurie.*

Report of Debate.

Mr. Champion : A summary of the results obtained so far from the all-India teak seed origin experiments organised by the Forest Research Institute has been compiled here and circulated (p. 119). I have only to add that as happened with the European experiment on *Pinus sylvestris* on which our work was modelled, numerous difficulties have arisen in the attempt to make an equal start with all origins under trial at each centre, and we have fallen a good deal from the ideal aimed at. Taking everything into consideration, however, the start has been no worse than I anticipated, and if completed on the agreed lines, should supply valuable information before many years, particularly for localities where all seed has to be imported. As expected, in a general way the local origin appears to be most suited, but exceptions may occur in the lower quality tracts. I wish to take this opportunity of stressing once more the importance of the short term investigation which permits of the statistical comparison of the growth of plants of different origins during their first few years without the complication of site differences inevitable in the larger plots which cannot be replicated. (This point was discussed in the Experimental Garden.—*H. G. C.*). In view of the difficulties which have arisen, I would again ask those concerned to do all possible to make co-operation include free supply of the limited quantity of seed needed. (Mr. Champion then proposed the resolution ultimately adopted).

Mr. Mohan : I would like to draw attention to the need for an accurate description of the seed. For this a microscopic examination of the seed is of importance. From a section of a seed examined under the high power microscope a lot of useful information can be collected and those investigators who have done this work can to a certain extent [illegible]

[illegible] botanist is not going to help us here but a solution has been put forward by Huxley, and probably some sort of technique can be evolved and work on this line can be very useful.

Mr. Champion : It seems fairly evident that if this special examination of the subject is called for, as it is in certain cases, it should be done at the Research Institute here as we would have done with teak, had we thought it necessary. We have the facilities here and there is no necessity to spend hundreds of rupees on more compound microscopes.

Mr. Mohan : But would the Institute be prepared to examine anything we send up ?

Mr. Champion : If you ask us to count the chromosomes of several hundred nuclei the answer is no.

Mr. Mohan : I have my microscope but I have not got a microtome. Will the Institute give us the instrument on loan ?

Mr. Champion : I think the Institute would be prepared to
reason provided a case is made out for the necessity of it. It
in investigating a special line in a narrow field
the results could be used for

for seed examination record all the details visible under a low power microscope, such as were collected for the *Pinus sylvestris* investigation, but so far I have seen very little practical use made of such data.

We have also to decide how to maintain these plots. We have taken a lot of time and trouble in ensuring initially comparable conditions of growth but the maintenance of comparability is equally difficult. As regards first thinning, it will probably be best to thin as far as possible at the same average height for each origin. The first one or two thinnings might be regulated primarily by number of stems per acre after thinning, and thereafter we can perhaps follow Nilambur *n|d* curves as our standard for reference. A settled policy is most important.

Mr. Watts : We have two sets in the Central Provinces, one of which is completely stocked and in the other, three plots have been a failure. I think sample plots should be laid out at once and I want to lay them out next season. The cleanings cannot possibly wait any longer.

ITEM 8.

Problem of the pure teak plantation.

A paper was received from Madras (p. 126), shorter notes (p. 129) by the Central Provinces, Burma, Bengal and Bombay ; that from Madras was circulated to all concerned before the conference.

The debate was opened by Mr. Dhanukoti Pillai (Travancore) and representatives of all teak growing provinces took part. The question of relative incidence of bee-hole borer attack in plantations and natural forest was discussed and the effect of borer holes on the value of the timber ; Dr. Beeson and Mr. Seaman of the Research Institute joined in this portion of the discussion. Prevalence of *Loranthus* attack and the risks of soil erosion were also considered.

The following resolution was proposed by Mr. Dhanukoti Pillai (Travancore), seconded by Mr. Ramiengar (Mysore) and passed by the conference.

RESOLUTION ON ITEM 8.

Resolved that—

The Central Silviculturist be requested to revise Bulletin No. 78 in the light of the experience acquired since it was published.

Report of the Silviculturist, Forest Research Institute, on action taken on the Resolution passed by the 1929 Conference.

The 1929 resolution was as follows :—

Resolved *that, recognising that the production of crops of teak without either admixture or an undergrowth is inexpedient, and in view of the inadequacy of our present knowledge of the methods by which a mixture or undergrowth can best be obtained, this conference recommends—*

(1) *that the Central Silviculturist should collect and publish as a bulletin all information at present available,*

(2) *that experiments dealing with the admixture of teak with other species, or with the introduction of an undergrowth should be undertaken by the Silviculturists of the provinces concerned, and*

(3) *that the subject should again be discussed at the next conference when further experience has been acquired.*

In accordance with the recommendations made in this resolution, the following action has been taken.

(1) The Central Silviculturist collected and published all available information on the subject as *Forest Bulletin* 78 in 1932. This was followed by an article by Mr. Blanford in the *Indian Forester* (July 1933) with a supplementary note by the Central Silviculturist.

(2) Experiments are in progress on the admixture of other species in several provinces but have hardly yet had time to give very definite results. There is now however a general feeling that correct cleaning and thinning treatment will result in most places in a suitable undergrowth to meet most of the objections raised.

(3) Much work has been done in Burma on the relative incidence of Beehole borer damage in teak plantations.

Item 8.]

PAPER (I).

By M. V. LAURIE, *Silviculturist, Madras.*

DEVELOPMENTS AT NILAMBUR SINCE THE LAST CONFERENCE.

General.—The problem of the pure teak plantation seems to have lost much of its importance in Madras since it was discussed at the last silvicultural conference. This is chiefly due to the improved methods of formation which have overcome the difficulties in regenerating second rotation plantations, and also to the general opinion that has grown up but which is still unsubstantiated by statistical evidence, that second rotation plantations are not noticeably inferior to the first rotation plantations on the same areas. The various points mentioned in Bulletin No. 78 on this subject are treated in the same order, and notes on them given as far as they concern Nilambur.

2. *Falling off in rate of growth.*—The apparently poorer quality of the earlier second rotation plantations was due to difficulties in regenerating them and failure in many cases to get reasonably complete initial stocking. The resultant regrowth of weeds and climbers after the first two or three years was so prolific that, even in spite of expensive weedings the teak was retarded and much of it suppressed. These difficulties have now been overcome and fully stocked plantations are now the rule from the start. There is no evidence that these plantations are growing any slower than the first rotation plantations, and the rate of growth in some of the best areas is phenomenal. Statistical evidence to confirm this throughout the lifetime of the teak in the second rotation is however still lacking.

3. *Fluted boles.*—Fluting has never been considered serious at Nilambur.

4. *Epicormic shoots.*—These are very prevalent especially in older plantations. Exposure of the boles of even old trees to side light (by the felling of an adjacent compartment for instance), produces a dense crop of epicormic branches right down the trunk to ground level. In young plantations dense crops of epicormic shoots occur after defoliation but on closure of the canopy these seem to disappear quite quickly and it is doubtful whether the damage to the quality of the timber is appreciable from this cause. At Mount Stuart the plantations are particularly bad in the matter of persistant epicormic branches. It is not known whether this is due to :—

(1) *Defoliation*—which occurs frequently.

(2) *Over-crowding*—the plantations are in many cases underthinned—and the crop of epicormic branches is stated to occur just after a thinning (the theory being that possibly the crowns were too constricted to respond properly and hence on opening up the canopy produced a crop of epicormic branches instead.)

(3) *Seed of bad origin.*—Much of the seed used in these plantations is reported to come from Punachi Range, where the forest is a more open branched type.

It is possible that the bad epicormic branching may be due to a combination of these factors. The natural forest teak at Mount Stuart is particularly straight and unbranched.

The conclusion is—as before—that the production of epicormic shoots is generally the result of unfavourable conditions, and there is little evidence to correlate it directly with species purity. It is impossible to believe however that bad persistent epicormic branching, such as is seen in the Mount Stuart plantations does not produce bad knots and reduce the quality of the timber. The remedies appear to be to deal as effectively as possible with the various factors that are considered responsible—(defoliation, underthinning, and origin of seed). At Nilambur, in compartments with a mixture of bamboos, the teak appears to be particularly free from epicormic branches, and it is possible that the underplanting of bamboos may reduce epicormic branching. Some attempts at underplanting with *Cephalostachyum pergracile* at Nilambur look very promising.

5. *Defoliation.*—No measures have been attempted to control defoliation by mixtures in any form at Nilambur. It is generally considered (though there is no statistical evidence to support it) that the damage or loss of increment from defoliation is not serious enough to warrant the expense of introducing mixtures in plantations. The retention of a natural undergrowth of shrubby species will, it is hoped, help to reduce the attacks and increase the number of predators.

6. *Bee-hole borer.*—**Does not occur in South India.**

7. *Damage by other insects and parasites.*—Attacks by *Phassus malabaricus* in young plantations occur but are not severe enough to warrant special measures. *Loranthus* also parasitises the teak to a limited extent. A severe epidemic defoliation has occurred this last year from a locustid (*Aularches miliaris*) in localised areas and there are indications that the attacks have increased during the last two years. It is not known whether this is likely to become a serious pest in teak plantations. The matter has been referred to the Forest Entomologist.

8. *Soil deterioration.*—Evidence that the soil deteriorates under pure teak is lacking at Nilambur. The original difficulty in regenerating second rotation plantations it apparently not due to soil deterioration as previously stated, so much as to lack of a good burn and faulty regeneration methods. The hardening of the soil in pure teak plantations appears to be prevented by keeping a natural undergrowth on the ground.

9. *Soil erosion.*—Erosion of the surface layers of the soil in teak plantations has not been noticed to any serious extent in Madras and has not been considered an important factor in soil deterioration in the second rotation.

10. *Lack of material for an adequate burn.*—The retention of all underwood combined with a policy of heavy thinnings provides a fair amount of material for a burn, though even so the burn after exploiting first rotation plantations is very poor and patchy compared with the burn obtained after clearfelling mixed deciduous forest.—Underplanting with bamboos (*Cephalostachyum pergracile* shows signs of being suitable for this purpose) should go a long way to remedy this.

The lack of a good burn is, however, no longer regarded as a serious obstacle to regenerating felled plantation areas. Success depends upon adequate weeding practice in the first year, and is helped moreover by better methods of introducing the teak. The previous practice of entire transplanting, which, though it gave satisfactory results in normally good years, was very liable to give bad stocking in an unfavourable year has been superseded by stumping or direct sowing, the former becoming more popular every year. The great advantages in early stump planting have been realised and this method is being adopted more and more at Nilambur.

The chief change in weeding practice at Nilambur is the adoption of scrapings or forkings (with one or two weed cuttings) instead of numerous weed cuttings. As a consequence, the teak grows faster in the first year, weed regrowth is less, especially in the second year, and total weeding costs are reduced. The dangers of a poor burn are completely overcome, and it actually costs considerably less to establish a second rotation plantation than a first rotation plantation owing chiefly to the lower costs of clear felling and burning, which more than compensate for any extra cost of weeding that might be caused by a poorer burn. It is also found to be worth while to dispose of the lop and top at Nilambur as the revenue obtained thereby more than pays for any increase in weeding costs due to a poorer burn.

11. The attitude adopted in Madras towards the various remedies proposed in Bulletin No. 78 (paragraphs 14 to 24) is as follows :—

(*a*) *Retention of mixed forest type.*—The much greater financial advantage from pure plantations—even of poor quality—as well as the greater simplicity in management make the retention of patches or areas of mixed forest type in plantations undesirable. Complete plantations at 6′ × 6′ spacing are the aim in the earlier stages.

(*b*) *Mixture by junglewood regrowth.*—The retention of as much junglewood undergrowth as possible without detriment to the teak is the aim. In II and III Quality areas this regrowth is usually fairly adequate. In I Quality areas, the canopy closes sooner and a clean floor results by the time the first thinning is due. It is laid down in all teak plantation working plans that all re-growth of junglewood species whether by coppice or from seed shall be retained and shall not be cut when weeding, provided that such regrowth does not do extensive damage to the teak by suppression. Actually the present methods of weeding by scraping or forking destroy a great deal of such junglewood regrowth in the early stages of a plantation, and in taungya areas (*e.g.*, in the Wynaad) practically all such regrowth is removed by the cultivators. In spite of this, a considerable amount of regrowth of woody shrubs and trees comes in in the second and third years, but this again disappears partly or completely when the canopy closes before the first thinning. On the whole there is more regrowth on the ground in mature or nearly mature plantations than in young plantations, which is what is wanted.

(*c*) *Mixed plantations.*—The custom of sowing rosewood at the same stake as teak is being continued as a regular routine measure at Mount Stuart. A fair proportion—probably 25 per cent. approximately—of the stakes, have rosewood seedlings as well as teak after three years, but much of it is small owing to shading by the teak. It will be interesting to see how the rosewood responds at the time of the first thinning. Parts of these plantations show signs of giving a valuable mixture of rosewood and teak, while in other areas the rosewood has completely disappeared.

(Various mixtures are being tried in strips at Kannoth in the Wynaad the species experimented with being rosewood, *Pterocarpus marsupium, Swietenia macrophylla, Artocarpus hirsuta* and a little *Pterocarpus dalbergioides*, but these experiments are not so much directed towards avoiding the disadvantages of pure teak plantations as towards finding the most suitable species for these localities, as it is not known whether they are altogether suitable for teak).

(*d*) *Strip or group planting.*—Apart from the experiments mentioned above, strip or group planting with other species is no longer being tried. The attempts from 1926 to 1929 with strips of rosewood at Mount Stuart were such a fiasco that the idea of this method of making a mixture has been practically dropped. An essential for strip mixtures is that the different species used should grow at approximately the same rate as teak throughout its lifetime so as not to suppress it nor to allow the trees on the edge of the teak strips to produce extensive side branches.

(*e*) *Suitable thinning procedure.*—This appears to be very important both as regards obtaining maximum increment and as regards maintaining a suitable undergrowth. Experiments are being started to determine best methods and cycles of thinning but will not yield results for a number of years.

(*f*) *Soil cover crops.*—Experiments with *Tephrosia candida* have not been going long enough to assess its value as a cover crop accurately. If introduced in the first year, it is a bad weed, retards the rate of growth of the teak and has to be cut back frequently (Experimental Plot No. 124, Nilambur). If introduced in the second year, it does not help as a weed-suppressor until the teak is out of reach of the weeds. In the third year of the plantation, when itself two years old it forms a very nice cover crop, about 6 to 10 feet high, suppressing the weeds and forming a good mulch of dead leaves on the ground. We have no statistical evidence that the growth of the teak is improved, but the District Forest Officer, Nilambur, reports that teak areas with *Tephrosia* undergrowth retain their leaves longer in the hot weather and look healthier than areas without *Tephrosia*. The *Tephrosia* dies out by suppression in the 4th or 5th year of the plantation. It seems probable that the beneficial effect if any of this cover crop in improving the soil will only last for a few years in the younger stages of the plantation and that the ultimate effect will be negligible. What appears to be required is a cover crop or undergrowth that will maintain or improve the condition of the soil throughout the life of a plantation and especially in the last ten to twenty years before felling.

Experiments have been started with *Leucaena glauca* and with *Cajanus* but have not yet yielded any results.

Underplanting with trees.—Experiments in underplanting II and Quality plantations 37 years old with mahogany and *Cedrela toona* have not very promising results, growth being slow and casualties due chiefly to and browsing being many. Some of the larger plants appear to be and should go ahead at the next thinning.

object of such underplanting requires careful definition. If it is hoped to get a subsidiary yield from a valuable timber species, it necessary to plant it at such a time and thin the teak in such a way that the underplanted species will attain a saleable size by the time the teak is due for clear felling. It is also necessary that the cost of introducing the subsidiary species, and the value of any sacrifice of the teak made in order to bring it up to a saleable size by the end of the rotation should be more than covered by value of the subsidiary species as a soil improver and a benefit to the teak plantation as well as by its sale value at the end of the rotation. On the face of it, it seems unlikely that the introduction of a valuable species with the idea of getting a timber yield will pay, as it inevitably involves sacrificing a good deal of teak.

If, on the other hand, underplanting is undertaken solely with the idea of improving the teak plantation, a much larger choice of species is available and those which will grow under the shade of teak and which will not compete with it in the upper canopy are to be preferred. The crux of the whole question is whether the competition from such underplanting will reduce the rate of growth of the teak, and if so, whether the increment so sacrificed will be recovered in subsequent rotations by maintenance of soil fertility.

(*h*) *Underplanting with bamboo.*—At Nilambur, underplanting with *Cephalostachyum pergracile* and *Bambusa arundinacea* has been done on an experimental scale, and successful results have been obtained from direct sowings of both these species. It remains to be seen how far the objects of underplanting will be attained with these species.

The obvious benefits of introducing bamboos are (1) the production of material for a burn, (2) the production of bamboos for floating, (3) the prevention of epicormic branching of the teak and the production of cleaner timber (believed to be the case but not definitely known). Other possible advantages are the maintenance of soil fertility—(unlikely), the reduction of defoliation (not known). Possible disadvantages are (1) root competition with the teak and consequently loss of increment, (2) crown competition with the teak (in some species only—*e.g.*, *Bambusa arundinacea*), (3) possible soil deterioration.

(*i*) *Insect control measures.*—No direct control measures are adopted to check defoliation. It is hoped, (but not proved) that the maintenance of a mixed understorey may help to check defoliation.

(*j*) *Fire protection.*—All plantations in Madras are rigidly fire protected. The advisability of doing so has never been questioned.

12. *General Summary.*—(*i*) There is no proof of deterioration of soil under pure teak. Experiments to determine definitely whether such deterioration exists appear to be the first requirement since all the other measures proposed or discussed accept the probability of such deterioration.

(*ii*) The desirability of retaining an undergrowth, of introducing mixtures, of underplanting with trees or bamboos has been discussed from various aspects. The most important point to be determined however is whether such mixtures or underwoods will retard the growth of the teak, and if so, whether such loss of increment in the first rotation will be compensated by maintained quality in the second and subsequent rotations. These questions can only be answered by carefully controlled long term statistical studies extending over many years, and covering crops of more than one rotation on the same piece of ground.

Notes.

(*i*) *Central Provinces.*—Until very recent years, no teak plantation work had been undertaken in the Central Provinces except on an experimental scale. Most of the C. P. teak forests are what would doubtless be regarded elsewhere as a poor scrub type of forest. C. P. III and IV*a* qualities are the most common, in which height seldom exceeds 70 ft. and the girth 4 ft. These forests are mostly worked under a coppice system, and reproduction is usually satisfactory without artificial assistance. Teak, being a prolific coppicer and not liable to damage by browsing of deer or of cattle, is greatly favoured against other species by a coppice system, and such species are liable to be gradually eliminated. Recent working plans have included prescriptions to foster a mixture of trees of miscellaneous species by favouring such trees in thinnings or by reserving them as standards in conversion or coppice fellings in forests where teak is tending to become pure.

Artificial teak plantations on a considerable scale have recently been started in two divisions (Bilaspur and South Chanda). Teak has been planted pure in most areas, but almost everywhere there is abundant regrowth of bamboos from the previous crop, and the bamboos, together with the coppice and natural seedling reproduction of miscellaneous tree species, are likely to form a suitable proportion of the forest. It is generally agreed that an admixture of other species in teak plantations can generally be obtained naturally in the Central Provinces and that artificial measures are not necessary, especially as our plantation work is mostly being undertaken in bamboo forests and not in the more arid trap areas of the Central Provinces, where teak shows the greatest tendency to form pure crops.—*H. C. Watts, Silviculturist.*

(*ii*) *Burma.*—In considering the desirability of issuing a revised edition of Forest Bulletin No. 78, I note as follows :—

(*a*) Some Burma Notes on the problem by Mr. Blanford were published in the *Indian Forester* for July 1933 and would certainly require to be included in a revised Bulletin.

(*b*) Definite research on the incidence by Beehole borer in continuation of that published in Burma Bulletin No. 29 of 1932 is being continued both by the Forest Economist and the Forest Entomologist, and should shortly be available. Further knowledge will be then available under this head.

(*c*) Some small experiments in the introduction of an undergrowth have been put down, the last set consisting of the sowing this year of *Dalbergia latifolia* in thinned plantations.

(*d*) Mixtures (*a*) teak and *pyingado* quincunx (*b*) teak widely spaced in a *pyingado* matrix have been put down recently.

Note.—(*c*) and (*d*) above will not produce any results for some time.

2. As far as Burma is concerned, I do not think any revision urgent. If revision is decided upon then both Mr. Blanford and Mr. Shirley should be asked for opinions, Mr. Scott should be asked for a revised opinion on beehole and Mr. Atkinson on insect problems generally. (They have not been asked at present). Except for beehole borer any alteration from Burma at the present stage would depend more on changed views than on definite research results and I think myself that opinion in Burma remains largely unaltered *i.e.*, that correct thinning treatment will override most of the other objections.—*R. W. V. Palmer, Silviculturist.*

(*iii*) *Bengal.*—Teak in Bengal is an exotic and there is no natural teak for comparison. All teak plantations are pure and so no comparison of teak really growing in a mixture can be made. The following are my personal observations and refer to pure teak plantations only. The references are to *Forest Bulletin No. 78.*

Para. 3.—Sample plots in pure teak plantations in the Chittagong Hill Tracts do not show any falling off in rate of growth and health after 10 to 20 years. We have plots up to 44 years of age.

Para. 4.—From observations I would say that fluting is much more noticeable on areas unsuitable for teak. Fluting is more severe and frequent in the Chittagong Hill Tracts where teak has been put out on flat areas along the banks of rivers where drainage is poor, soil clayey and the area is waterlogged during the rains, than on the slopes further in where the drainage is good. Fluting would also appear to be worse in plantations that are underthinned, this may be of course due to the fact that it is the badly fluted stems that would naturally be removed in thinnings whenever possible in a correctly thinned plantation.

Para. 5.—The formation of epicormic shoots is more closely related to thinning than anything else. Underthinned plantations produce many epicormic branches which persist for a long time after the plantation has been properly thinned. Plantations thinned correctly from the start do not show anywhere near as many epicormic branches. Teak plantations are extremely sensitive to over-crowding and each thinning should be so carried out that by the time the next one is due, the crowns are only just closing up. Natural suppression should never be allowed to occur in teak plantations.

Para. 8.—In the Chittagong Hill Tracts pure areas of teak and *gamari* have been put out adjoining each other in nearly every years plantation. Since 1931 *gamari* has been severely attacked by *Loranthus* (*Loranthus scurrula*), but the *Loranthus* has not yet been reported as occurring on the teak.

Para. 10.—Only in areas where no undergrowth exists is soil erosion so bad that the roots of the teak become exposed.

Para. 21.—*Under planting and mixture with teak.*—Since the last Silvicultural Conference in 1929, experiments have been carried out in under-planting teak with certain species such as *Bambusa tulda, Dichopsis polyantha, Artocarpus chaplasha* and *Swietenia macrophylla*. The most suitable species was found to be *Dichopsis polyantha*, but *Artocarpus chaplasha* and *Bambusa tulda* were quite successful in areas where there was no danger from damage by elephants. A small even-aged mixture of quinqunx planting with *jam* (*Syzygium jambolanum*) in the centre was carried out in 1932 and the *jam* appears to be doing quite well.

It is not considered necessary or profitable to underplant or mix teak in Bengal. In the Chittagong Hill Tracts division (where most teak is put out) after the first thinning, which is heavy ' D ' grade and done when six growing season old, bamboos—chiefly *Bambusa tulda* and *Melocanna bambusoides* come up as an understorey ; these are an extremely valuable crop and any species introduced will only come up at the expense of the bamboos and would not as a rule be as profitable. Even-aged mixtures will be expensive, because a very dense canopy is required to kill out the dangerous climber *assam lota* (*Eupatorium odoratum*), and this is only satisfactorily done by a pure teak canopy which closes up quickly and so suppresses the light demanding *assam lota.*

For the reasons mentioned above it is not proposed at present to carry out any further experiments with underplanting or mixing teak.

Para. 20 (Soil cover crops).—It would be interesting to verify the suggestion that *Eupatorium* may be helpful as it keeps down weeds and climbers. In Bengal it is a most dangerous climber and covers the whole of the plantation from the 2nd year, and if not cut frequently will climb up and pull down or smother the young teak, until such time as the canopy is closed and the climber which is luckily light demanding is killed out.—*C. K. Homfray, Silviculturist.*

(*iv*) *Bombay.*—The following additions and corrections to Forest Bulletin No. 78 are suggested. The summary of Section 15 " Retention of mixed forest type," on page 18 appears somewhat misleading as regards the Bombay *rab* method. It is quite correctly stated in the beginning of the section that this method is particularly developed in the lower quality areas, where there is commonly so intensive a demand for smallwood that special steps have to be taken to ensure retention of enough debris to get a satisfactory burn even on the patches. From this it follows perhaps by implication, though it is not actually stated in so many words, that the whole of the annual coupe is clear-felled, or at any rate a considerably greater area than the patches which are artificially regenerated. Since these patches therefore are surrounded chiefly by natural regeneration of mixed species of the same age as the planted patches, the effect of root competition is probably not very great. There may be some adverse competition from the roots of stumps which coppice but since teak only forms a small percentage of these, it may well be that on balance the competition affecting the young teak round the edge of a *rab* patch might actually be less than that at the centre of the patch, where each individual teak would be surrounded by others of the same age and therefore tapping the same soil levels.—*E. A. Garland, Working Plans Officer.*

Item 8.]

Report of Debate.

Mr. Pillai : At the last conference the subject was gone into exhaustively. During the past four years some further information has been collected, but of course within so short a period a great deal could not be expected and it has not taken us very much further. The main points that came up for discussion at the last conference were the formation of epicormic and the deterioration of soil in the second rotation. So far as Travancore is concerned, we have been tackling the problem in our own way. All our plantations have been raised almost pure, and so far we have not encountered any of the difficulties reported to the last conference. We have now 12,000 acres of pure teak plantations and almost all of them are free from the defects mentioned. In the earlier plantations we left a belt of forest to separate one year's plantation from another but we found that this belt was not serving any useful purpose, and in the later plantations we have discarded even this. With regard to the formation of epicormic branches it was pointed out that this formation was brought about by under thinning but we have found that with us their formation was due to over thinning and sudden admission of side light.

With regard to the deterioration of the soil, fortunately that problem has been solved now. The latest information received is that the difficulty experienced in raising the second crop was due partly to lack of knowledge and it is now said that with proper care and a little trouble the difficulty can be obviated and soil deterioration is not apparent. With regard to insect attack we have the usual defoliation in Travancore but this does not cause any serious damage. Defoliation occurs just before the rains and as soon as the rains fall it disappears. Also we have detected no case of bee-hole borer in our plantations. Then with regard to the admixture of other species in plantations, we have been trying that too. In one plantation we underplanted the teak with *Artocarpus hirsuta* after 15 years but we gave this up later because it was found that it was not in any way improving the soil or giving us better results. In another place we tried *Xylia* but its growth was so quick that very soon it overtopped the teak and we had to cut back. We are now introducing mahogany in a few of the old plantations. The result is still to be known but I am afraid that this also is likely to overtop the teak in course of time. We always have some sort of natural undergrowth in all our plantations. That may be because they are sited on very suitable soil specially by the side of streams. The whole area as a rule is covered with undergrowth about fifteen or twenty feet high and our soil is nicely protected so that erosion and leaching of soil do not affect us at all. We carry out a sort of weeding and cutting back before thinning but I am stopping this

In concluding, I would say that the points discussed do not for the most part apply to Travancore.

Mr. Villar : So far as Burma is concerned, and with the exception of the problem of the bee-hole borer, any alteration in Forest Bulletin No. 78 would be based more on changed views than on any definite research results. Opinion in Burma remains largely unaltered and it is chiefly difficulties connected with technique which we encounter in Burma. With regard to the bee-hole borer, probably you have all had a copy of the Burma Forest Bulletin No. 29 of 1932. This was a result of a sawmill analysis of bee-hole in teak posts which were extracted from plantations. What we discovered as the result of that investigation was that the incidence of bee-hole borers definitely follows the rainfall, that is to say the more the rainfall the heavier the bee-hole borer. This applies only to the main teak areas. When you get outside the main teak belt down in the south eastern side of Burma over in the Moulmein direction, where there is very heavy rainfall, the bee-hole borer is practically non-existent. The bee-hole borer also gets less and less as you get into the dry zone of Central Burma. This investigation is now being carried further. We have been provided with additional funds and a much larger range of analyses is being carried out and I hope that within the next few months we shall be able to bring out another bulletin which will confirm the results given in the previous bulletin No. 29. As regards undergrowth, certainly in Burma we always encourage undergrowth as much as possible.

Mr. Laurie : I have submitted a note which has been circulated giving the general attitude in Madras towards this subject. One of the most important points appears to be whether we get degeneration of the soil and the general quality under pure teak. At the last conference the view was generally held that we did. The doubts that were then expressed appear to have been dispelled to a very great extent and there is, as far as we know, no evidence to prove that there is any appreciable deterioration of the soil and quality under pure teak. It does, however, seem to be an important question and we do require statistical evidence to show whether we get this deterioration or not. We are starting plots in first rotation plantations which are very nearly due for final felling and they will be continued on the same area in the second rotation so as to determine any alteration in quality.

Another important point is, if you have an undergrowth in a teak plantation, does the competition of that undergrowth with the teak reduce its rate of growth appreciably ? I think Java have carried out a large number of statistical investigations on this subject with, I believe, both natural and artificially introduced undergrowth, and they have shown that in almost all cases teak with a clean floor under it grows faster than teak with any sort of undergrowth. This should not be taken as meaning I am advocating not allowing an undergrowth. (No mixture or plot underplanted with tree species grew better than pure teak with a *Leucaena* soil cover.—H. G. C.). If we can show that our undergrowth is not doing good in any way such as maintaining fertility or reducing insect attack, then are we justified in keeping undergrowth ? That again seems to require investigation. It is rather difficult to know how to tackle the problem but I have no doubt a scheme could be evolved if necessary. Regarding mixtures, the general view in Madras is that since we have not shown that there is any deterioration in teak we do not feel justified in diluting a very valuable crop with a less valuable species.

Mr. Garland : In Bombay as regards teak plantations the principal thing that we are worried about at the present moment is *Loranthus*. It seems we are not troubled with it at all in the ordinary mixed forests but it does seem to be attacking the plantations rather badly. Defoliation we are not very worried about. Our experience with regard to epicormic branching is that it is not due to too little thinning or too much thinning but to late thinning. That is to say that when a crop that has been kept too congested in youth is suddenly opened up, it merely takes advantage of the increased light, and produces epicormic branches.

With regard to underplanting with other species, attempts to find suitable species for mixture with teak have been definitely abandoned as none of those that have been tried have proved satisfactory and our attention is now concentrated on our cleaning and thinning so as to obtain a sufficient understory of those species which regenerate themselves naturally. In other words we are not now making any attempt to produce any crops in our plantations other than teak and the subsidiary species are encouraged simply for their value for the protection or improvement of teak and possibly for their effect on defoliators. If they threaten the teak they are always sacrificed. Mr. Laurie raised the point I think that experiments have been made which prove that teak grows faster without an undergrowth. I should like to know up to what age of teak those experiments relate to. It strikes me from what I have seen of it that although it may grow faster in youth, it may retaliate by stagnating later on and the end result is probably poorer.

Mr. Champion : The Javan experiments were continued over 16 years and though I believe I am right in saying that they are still in progress, Mr. Garland is right in suspecting that they only cover a relatively short period of the life of the teak. His suggestion is I think very probably correct, and there is a very definite possibility, that later on they will get a check. It is a point we ought to bear in mind in our own investigations.

Mr. Watts : Plantation work on a large scale has been undertaken only in recent years in the Central Provinces in Chanda and Bilaspur divisions in bamboo forests, and in forests where regrowth of bamboos and miscellaneous species is so vigorous that the artificial introduction of a mixture appears unnecessary. The question of mixtures has arisen in a more acute form in our coppice areas, where we are now finding that by clear fellings, we are encouraging the fast growing teak and discouraging the slower subsidiary species, which are also at a disadvantage as they suffer most from the browsing of deer. To maintain a mixture of miscellaneous species, our working plans now usually prescribe their reservation in coppice coupes in areas where teak is tending to become pure.

Mr. Homfray : It was stated that there was a feeling that the rate of growth in pure plantations fell off after some years. This is not the case in Bengal and we have plots up to 44 years of age still growing very well. Fluting is much more noticeable in areas unsuited to teak. We have some old teak on flat areas along the banks of rivers that are liable to water logging, here the fluting appears to be much worse than on the well drained slopes further on. I am in full agreement with Mr. Garland that the formation of epicormic branches is more closely related to thinning than anything else. Pantations under thinned or left unthinned too long develop epicormic branches when they are eventually opened up by thinning and such branches seem to persist for ever, getting larger each time a subsequent thinning is made. Plantations thinned correctly from the start do not show anywhere near as many epicormic branches. Mr. Garland mentioned the attack of *Loranthus* on teak and in this connection I may add an interesting observation. We have large areas of *Gmelina arborea* and teak plantations adjoining each other and in a few cases intermixed. The *Gmelina* since 1931 has been very badly attacked and in some cases whole plantations were killed out. I think I am correct in saying that not one single teak has been attacked. A large proportion of the badly attacked *Gmelina* is on a wet damp soil unsuitable for it, whereas the majority of the teak is on a well drained soil. I feel that resistance to attack is closely related to the suitability of the species to the locality concerned.

Mr. Laurie pointed out that in Madras erosion on account of the absence of ground cover was not really an important factor. In the Chittagong Hill Tracts teak is put out on very undulating ground and in some cases on steep slopes, and if we did not have an under cover or storey we should definitely get very bad soil exposure indeed. As regards an understorey, bamboo comes up after burning and provided the thinning is heavy enough (D grade) in the 5th year, it comes up well and provides a valuable revenue. Therefore the question of introducing an understorey does not arise in Bengal. In the bulletin, Burma is reported to have said that "Assam lota" *Eupatorium odoratum* is considered helpful as it keeps down weeds and climbers. I should like to ask Burma if they are still of the same opinion. In Bengal we look on it as the worst climber we have and we spend a considerable amount of money cutting it back each year so as to prevent it completely smothering the adjoining tree crop.

Mr. Osmaston : With regard to mixtures we have few crops that can give useful comparisons. In both the Puri and Angul divisions, teak is planted pure, but in Puri we are lucky in that an evergreen undergrowth comes in under the teak in 5 or 6 years, so that the teak can hardly be described as a pure crop. In Angul on the other hand, the undergrowth is either very scanty or absent. In this connection it is interesting to record that the only semi-mixed plantation that we have in Angul is a pure crop of about 50 years age surrounded by *sal* forest. In this plantation nearly every teak tree is attacked by *Loranthus*. But in other respects it is healthy and regenerating itself naturally.

Mr. Garland : In regard to Bombay I omitted to touch on the question of bamboo which some people say they like and some say they do not like. Our experience is that it depends entirely on what bamboo you are dealing with. For instance, we dislike the large bamboo (*Bambusa arundinacea*) in our plantations as it definitely overtops and damages the teak. But in choosing a site for making a plantation this bamboo is useful if it is old as it gives a good burn and is exterminated sufficiently. But if young, however, much it may be burnt, it shoots up again and is a great nuisance

Mr. Laurie : Most of the old plantations at Nilambur are on flat ground and the question of erosion does not come in to any serious extent. The newer plantations are being extended to the lower slopes of the hills and we may have erosion trouble. The soil is very rich in humus and is of a stable type and the trouble is not likely to be serious. We need to know in view of the results reported from Java how much of a mixture of other species we are justified in keeping in our teak plantations, and whether that will reduce the growth of teak enough to make it a serious economic proposition. With regard to *Loranthus* we get a little in Madras, mostly in low lying places, as in Bengal. We have been introducing bamboos experimentally with the idea of getting a mixture. *Bambusa arundinacea* has been tried but I do not know whether it is going to be satisfactory because where we get a natural mixture of it, it tends to outstrip the teak. *Cephalostachyum pergracile*, which has been imported from Burma, appears to be a more suitable species for the purpose and we have had very little difficulty in introducing it. The experiments have not gone far enough however to enable us to say what it is going to be like later on. There again the question arises "Is this introduction of bamboos going to reduce the rate of growth of the teak" ?

Mr. Champion : The Javan data were given in Bulletin 78. The experiments were started in 1915 on teak 9 to 12 years old and they were reported on 15 years later roughly, so they deal with crops nearly 35-40 years old. It should be repeated that the pure teak crops had an undergrowth of *Leucaena*. It is obvious from the amount of work that the Burma Utilisation staff has put into the subject of bee-hole borer that the matter is one of first rate importance. I understand that, on the whole, opinion is hardening in favour of the belief that the percentage of damage is greater in the plantations than in the natural teak, a point which was at least open to discussion five years ago. Now if it is as serious as that, we want to know what the risks are of a possible extension and introduction of bee-hole borer into other centres. Burma teak timber is imported largely into India including some of the Madras ports and if the insects might be introduced in this way, we are incurring a rather serious risk. We would also like to know the general point of view from the timber testing expert just how far reasonable bee-hole attack does spoil the timber. Everybody knows that if a sleeper or a beam shows signs of insect attacks there is immediately a prejudice against it.

The question of *Loranthus* attack I think deserves further study. I remember when I was touring in Bombay some years ago I saw some *Terminalia tomentosa* plantations wiped out by *Loranthus* and the examples on *Gmelina* in South Bengal are truly spectacular. *Gmelina* seems particularly susceptible. Mr. Howard said that the growing of teak pure was an economic problem and that is really what we always get back to in discussing this subject. In Burma they have this bee-hole borer but so far we have had no comparable trouble elsewhere in India. Personally I hate the sight of pure teak plantations but every time we look on the financial side we have to admit that it is the best course. Even if plantations of any other species grew much better, it would give us a poorer return and that tends to apply more emphatically the poorer the locality quality, *i.e.*, in Quality III and IV for teak as in parts of Bombay, the Central Provinces and Mysore and elsewhere where it is the small teak that brings in the revenue. Where we have markets for small teak, it is a very good proposition and it is easier to raise a plantation of small teak than any other species we have tried. One or two species under special conditions are easier to get up but anybody with staff with of average ability but very little experience and training can gurantee to produce 95 per cent. stocking of teak and I think I can defy anybody here to promise that in any other species except under very special conditions. (The United Provinces' delegates dissented referring to the recent taungya work with mixed species to be inspected later in the week.—*H. G. C.*).

It is obvious that several of our problems in teak plantations generally, whether pure or impure, are likely to be affected by the origin of the seed used. The question of *Loranthus* attack may on general grounds be suspected to be connected with seed origin.

Mr. Seaman : I have been asked for information as to the comparison between plantation and naturally grown teak. So far as we have tested plantation teak, it has been on the average stronger than naturally grown teak but there are always exceptions, and I do not think the results have anything to do with the source of the material, plantation or naturally grown. The conclusion that I came to during the testing was that whether the teak grew in a plantation or whether it grew in a natural forest, if it was of favourable rate of growth, it was good teak, and if it was of an unfavourable rate of growth it was bad teak. We have not definitely tested teak infested with bee-hole borers here. I may be wrong but I understand that the bee-hole borer is not active in the dead wood but is active in the living tree. If that is true the answer to the weakening effect of the borer is very simple, it is a matter of how much of the wood is removed. You subtract the area of the bee-holes and the rest of the area is ordinary teak. No wood should be accepted for structural purposes if it contains active borers. If living borers are not present, however, the wood in the vicinity of the borer hole is perfectly sound, and there is no damage except the loss of volume due to the holes.

Dr. Beeson : On the question of the possibility of the introduction of the bee-hole borer into India, it may be noted that its present distribution is due to causes of great antiquity ; it is a Malayan species and stops short at the ecological barrier between Assam or Bengal and Burma. It could not be introduced into India in timber because it does not live in dead timber at all. It could only be introduced by a continuous area of teak-bearing forest. If you create that you pave the way for its entry into India.

Mr. Champion : Can you tell us how big a break is necessary to keep it out ?

Dr. Beeson : No. Altitude and climate are important factors with regard to the incidence of the bee-hole borer attack in plantation trees and in natural forests. I cannot speak with first hand information ; I can only give you my interpretation of the data of others. But to crystalise the position, I should say that the bee-hole borer incidence is a function of the rate of growth, and it does not matter whether it is a plantation tree or a natural tree.

Mr. Champion : Can you give us any suggested reason for this ?

Dr. Beeson : It is a question of the nutrition of the borer. Supposing there is a uniform attack in an evenaged stand, the survival (and hence bee-holing) is greater in the more vigorous trees, that is, the severity of bee-holing is proportional to the girth in trees of equal age.

Mr. Seaman : Can you give us about the limit of the rate of growth which is favourable to the bee hole borer because if a tree that grows 6—8 rings per inch is not excessively liable to attack that would be the growth to aim at.

Dr. Beeson : The conclusion we arrived at many years ago is that there is a point at which volume increment outstrips borer-increment.

Mr. Champion : Am I right in deducing from what Dr. Beeson has said that Burma forest officers in general do not see eye to eye with him on the question of relative incidence in forest and plantation ? Actually Dr. Beeson provides evidence favourable to the plantation whereas I understand Mr. Villar to say that plantation timber was definitely more holed.

Mr. Villar : As regards the incidence of the bee-hole borer in plantations and adjoining natural forests, the figures we have worked out so far show that it is about three times as heavy in the plantation as it is in the adjoining forest.

Mr. Champion : Bulletin 78 could be revised with no particular difficulty. I think we ought to have appended to it the information of the utilisation side because really the whole question turns on the latter. I think we should ask the Institute as a whole to revise the bulletin bringing out the utilisation side as well as the silvicultural side.

ITEM 9.

Regeneration of Tropical Evergreen Forest.

A paper (below) was circulated by the Silviculturist, Forest Research Institute, surveying information accumulated since 1929 particularly in Bengal and Madras which he had recently visited with the local officers. Further notes based on this survey were received from Assam (p. 152), Madras (p. 157), Coorg (p. 160), Burma (p. 160), Bengal (p. 157), and the Andamans (p. 159), and the Forest Economist contributed a memorandum (p. 158), dealing with the question of suitable species to be encouraged in the evergreen forests under intensive management.

The debate was opened by Mr. LAURIE (Madras) reporting the findings of a committee consisting of himself (Chairman) and Messrs. CHAMPION, DHANUKOTI PILLAI (Travancore), RAMIENGAR (Mysore) and PURKAYASTHA (Assam). Mr. TROTTER (Forest Economist) was present and amplified the remarks made in his memorandum. All interested provinces having been represented on the committee and agreed on findings, there was no further discussion.

The following resolution was proposed by Mr. LAURIE, seconded by Mr. DHANUKOTI PILLAI, and passed by the Conference.

RESOLUTION ON ITEM 9.

RESOLVED that—

1. *This Conference considers that the recognition of sub-types of evergreen rain forest is required for management in South India (Madras, Mysore and Travancore), that such a sub-division is a practical proposition, and that the provinces and States concerned should collaborate in arriving at a classification that can be accepted.*

2. *Experiments in natural regeneration and artificial regeneration be made on the lines indicated in the Central Silviculturist's note, and that Silviculturists in each province concerned should keep in close touch with the work being done in similar types of forests in other provinces. This Conference recognises the probable economic advantages of concentrated regeneration in the most accessible places.*

3. *Clear felling followed by artificial regeneration with evergreen species using cover crops and nurse crops has proved practicable at least in the early stages in Bengal and Assam. This method should also be investigated in Southern India. Such investigations should be kept on a strictly experimental scale, and should be paralleled by similar experiments in raising concentrated plantations under shelterwood.*

4. *Although past experience has provided examples of successful replacement of evergreen forest by deciduous crops, notably teak, expensive failures have also occurred. Extreme caution is therefore desirable in undertaking any such change on a large scale, and if, for economic reasons, it is desired to replace the natural evergreen forest by more valuable species, evergreen species or semi-evergreen species should be preferred. It is further considered that good general utility timbers are preferable to heavy constructional timbers or sleeper woods.*

PAPER.

By H. G. CHAMPION, *Silviculturist, Forest Research Institute.*

1.—*Introduction.*

The position of our knowledge and experience in 1929 was summarised in the following terms (Proceedings Silvicultural Conference 1929, p. 109) :—

> " Natural regeneration is often present in good quantity, and having received suitable help, has in some places been established by the requisite weedings and by avoiding too sudden exposure. Where deficient or small its quantity can usually be increased by lightening the middle canopy and undergrowth, and to some extent by sowing or planting.
>
> Artificial regeneration offers serious difficulties, particularly in view of the nature of the ground on which much of this forest occurs, and of the need of some shade for the early stages of its chief species—

factors rendering *taungya* operations nearly impossible, when in view of the danger from weeds, *taungya* would be doubly valuable. Locally, where there is a pronounced dry season and where the evergreen type has probably been invasive in the (recent) past, *taungya* and plantations of trees of the moist mixed type should succeed. In the most pronounced forms of evergreen with well distributed and heavy rainfall, *taungya* with technique adapted to the special requirements of the evergreen type species offers most prospects of success where *taungya* is possible, and where it is not, reliance must be placed on natural regeneration obtained, with some artificial help if necessary, prior to any considerable opening up of the canopy."

The Resolution passed by the Conference and "brought to the notice of Local Governments for such action as they may consider necessary" by the Government of India, recognised the desirability of solving regeneration problems *before* proceeding with heavy fellings ; it recommended research work on the lines suggested by the Silviculturist, and pointed out the need of a preliminary classification of sub-types. It can be said that the Resolution has generally been given effect in the forests concerned.

The first recommendation of the 1929 Conference has been fairly generally applied in practice in so far as heavy fellings in true tropical evergreen forest are hardly anywhere in progress at the moment. In S. Bengal clearfellings on a moderate scale are in progress, but are being restocked by *taungya* plantations of evergreen species and so are in keeping with the Resolution as the older plantations have now reformed a closed canopy. Primary and secondary moist deciduous or sub-evergreen forest including restricted patches of the evergreen species (notably *Dipterocarpus* spp.) is being clearfelled and replanted in Assam and S. Bengal, and regenerated naturally in the Andamans.

Special systematic research is in active progress for both natural and artificial regeneration in Madras and Bengal, whilst there are some experimental plots and miscellaneous investigations, mainly on natural regeneration (sometimes supplemented by sowing or planting) in Assam, Burma, Andamans, Coorg and Travancore.

2.—*Literature.*

Since 1929, contributions to the literature on the subject have been published concerning the chief tracts of evergreen forest, as follows :—

West Coast forests.—

1. *The Sholas of the Palghat Division—a study in the ecology and silviculture of the tropical rain forests of the western ghats.*—T. V. V. Aiyar, Ind. For. 1932, pages 414-432, 473-486.
2. *Working Plan for the Thadagam Valley and Bolambatty Block III Forests of the Palghat Forest Division, 1930-39*—M. H. Krishnaswamy Ayyar.
3. *Revised working plan for the Mount Stuart Forests, South Coimbatore Division*—M. V. Laurie, 1933 (Karian Shola Working Circle).
4. Working Plan for the Evergreen Forests of the Wynaad Division—A. N. Sharma, 1932 (in Press).

East Himalaya.—

5. *Scrap the Lot,*—W. R. Martin, Ind. For., 1932, pages 534-646.
6. *Aided Natural Regeneration of Hollock (Terminalia myriocarpa)*—A. R. Thomas, Ind. For., 1933, pages 334-341.
7. *Natural Regeneration in the Sadiya Frontier Tract*—L. J. Dela Nougerede, Ind. For., 1934, pages 421-431.
8. *Working Plan for Eleven Forest Reserves in the Lakhimpur and Sibsagar Divisions,* 1931-32 to 1940-41—C. G. M. Mackarness.

Sylhet—Cachar.—

9. *The regeneration of tropical evergreen forests (Rain Forest)*—R. N. De, Ind. For., 1929, pages 620-622.

Chittagong and Arakan.—

10. *The Artificial Regeneration of Tropical Evergreen Forest in S. Bengal*—H. G. Champion, Ind. For., 1934, pages 517-526.

Burma.—

11. *Working Plan for the Mytikyina Forest Division*, 1931|32 to 1940|41—E. W.

12. *Report on Aerial Reconnaissance, Stockmapping and Photography of the forest of the Tavoy and Mergui districts*, C. W. Scott, and C. R. Robbins, *Burma For. Bull.* No. 13, 1926.

Andamans.—

13. *Andamans Forests and their Reproduction*—B. S. Chengapa, Ind. For., 1934, pages 54-64, 117-129, 185-198.

Java.—

14. *The natural regeneration of the Goenoeng-Gedeh block*—E. Khamer, *Tectona*, 1933, pages 155-185 (The area described appears to be hill evergreen).

Malaya.—

15. *Regeneration of Evergreen forests in Malaya*—H. R. Blanford, Ind. For., 1929, pages 333-339 and 383-395.

Tropical America.—

16. *General and Successional Ecology of the Lower Tropical Rain forest at Barro Colorada Island, Panama*—L. A. Kenoyer, *Ecology*, 1929, pages 203-222.

17. *Some aspects of Silviculture in Trinidad*—C. Swabey, *Emp. For. Journ.* 1932, pages 222-231.

General.—

18. *An introduction to tropical Soils*—P. Vageler, Eng. Trans. by H. Greene, 1933.

19. *Soil, Vegetation and Climate*—G. V. Jacks, 1934.

20. *Laterite and laterite soils*, 1932, Imp. Bur. Soil Sci. Tech. Comm. 24.

In addition, there have been useful notes in several of the annual administration and research reports, particularly those of Madras and Bengal.

This new information may be summarised under the main heads as follows :—

3.—*Ecology.*

(*a*) *Soil.*—Information about tropical soils including those associated with rain forest has accumulated, and in particular has been collected in more accessible form for the general reader. The dictum previously quoted that this type of forest lives largely on the products of its own decay finds further support, and the fundamental disturbances to the soil equilibrium consequent on the removal of the cover are better understood. It is pointed out that in the tropics it is the living plant (the forest) which is the directly active soil forming agent, the dead residues decomposing so rapidly as rarely to persist in sufficient quantities and for sufficient time to affect the course of soil development. The rapid turn-over of plant nutrients is one of the most characteristic features of tropical soils, and is most marked in rain forest soils. If the forest is destroyed, the chief source of plant nutrients is lost and the soil quickly deteriorates. It is also clear that the formation of laterite is unaffected by any influences arising from the vegetation, being the product of simple tropical weathering of rock. Typical tropical red soils are very commonly incorrectly described as laterite.

(*b*) *Period of growth.*—Aiyar has collected some most interesting and useful information in the Palghat evergreen forests on the West Coast. He points out that vegetative activity is severely checked during the season of heavy rainfall, when no new leafing and practically no flowering occurs ; seed may germinate to anchor themselves to the soil but a minimum of above ground development takes place till brighter and less humid conditions set in. New leafing typically occurs in September—October and flowering commences in November. The same agencies must be at work in determining the seasonal history of teak when grown under a heavy rainfall—little growth occurs till the very wet period is over. An interesting recent example is the Megina V. Experimental working circle in N. Mangalore, where the rainfall is about 300 ins. but the existing forest mainly deciduous ; various species were planted in 1933 but largely failed and were replaced by teak stumps which happened to be available. This teak stagnated completely till the end of the really wet weather and then grew well through the cooler drier months being virtually evergreen.

4.—*Sub-types of Tropical Everygreen forest.*

West Coast.—The only published attempt at a classification of the associations within the Indian rain forest formation is that prepared for the Palghat division on the West Coast by Aiyar and adopted in the working plan. The tract considered is fairly centrally situated in the evergreen strip and is representative of it, and although somewhat different proposals might result from further studies in other divisions, examples of Aiyar's associations are recognisable a good deal north and south of Palghat.

The eight associations differentiated are :—

1. *Cullenia-Palaquium* (Syn. *Dichopsis*).
2. *Palaquium—Mesua.*
3. *Poeciloneuron—Palaquium.*
4. Reed (= *Ochlandra* spp.)—*Calophyllum.*
5. Reed—*Poeciloneuron.*
6. *Mesua—Calophyllum.*
7. *Vateria—Cullenia.*
8. *Vateria—Mesua.*

The status of these associations is very unequal and separation of those which are climatic climaxes would give a clearer and more useful picture. From Aiyar's descriptions, it would appear that Nos. 1, 2 and 6 should be considered as of this nature, occurring primarily at successively higher elevations, change of elevation here often connoting change in rainfall as well as temperature. The status of No. 3 is not fully worked out, but its occurrence is clearly conditional on moister conditions and it can probably be considered a climatic climax with heavier and better distributed rainfall than Nos. 1, 2 and 6. Nos. 7 and 8 appear from their localised occurrence in the neighbourhood of streams and on sheltered slopes to be edaphic variants on Nos. 1 and 6, whilst Nos. 4 and 5 are clearly localised edaphic climax forms of Nos. 1 and 3 respectively on swampy soil. A variant of No. 1 with a rather drier climate is a *Mesua—Cullenia—Palaquium* association.

It is suggested that comparable studies in a few typical districts scattered over the evergreen belt, say in Tinnevelly, Travancore, the Anamalais, Wynaad (Chandanathode), Coorg (Makut), Mysore (Agumbe), N. Kanara and in Ratnagiri or Kolaba should permit of the drawing up of a general classification for the West Coast rain forest. A notable gap in the Palghat contribution is *Dipterocarpus,* and *Hardwickia* is also missing. Whilst the relative prevalence of the commercially more important *Mesua, Hopea, Dysoxylum, Dipterocarpus,* etc., must not be over stressed in such ecological studies, they do happen to be also among the most important components of the forest from the biological point of view.

Three other variants which are fairly well-known are (*i*) *Hopea* type, especially in S. Kanara, (*ii*) *Gluta* type, found in the Tinnevelly hills, and (*iii*) *Balanocarpus* type, also in Tinnevelly, but possibly better considered as belonging to a transition from rainforest to rather drier types.

E. Himalaya.—**Mackarness** defines four main sub-types for the U. Assam evergreen, *viz.*,

(1) Two storeyed high forest in which *Dipterocarpus pilosus* (upper storey) and *Mesua ferrea* (lower storey) predominate.

(2) As (1) but *Shorea assamica* instead of *Dipterocarpus pilosus.*

(3) As (1) but *Altingia* with or in place of the *Dipterocarpus* and *Castanopsis* with or in place of *Mesua.*

(4) High forest of mixed woods with no single predominant species.

The first three are evidently variations on a single climax form characterised by the prevalence of the species mentioned and may be considered as associations, the inter-relationships of which have yet to be determined and described. The status of No. 4 is not discussed but the references to it make it decidedly doubtful whether it can possibly be a climatic climax—it looks as though it is either a seral stage—perhaps a stable preclimax under prevalent conditions in the development of Nos. 1—3, or more likely a retrogression stage due to shifting cultivation or fire.

The really important forests in Assam at present, and those with which the articles in the Ind. For. are concerned are those in which *Terminalia myriocarpa* predominates. These forests are evidently very largely confined to relatively new soils and are not the climatic climax. The *Terminalia* itself, though literally evergreen has few or none of the characteristics of the climax evergreens and its associates are mainly more or less deciduous. We do not yet know how much of the country carrying this riverain type has progressed to a stage at which it is ready to support the climax tropical evergreen type, and actually our interest in it as foresters will undoubtedly be to keep it in its present preclimax condition as the characteristic species are more valuable as timber and easier to regenerate than those of the evergreen forest.

Cachar.—No further information has been published on the Cachar evergreen ; a working plan with some account of the forests was drafted but not printed, and it is believed a special study was made by another forest officer but is not available.

Chittagong and Arakan.—The forest types in Chittagong and the Hill Tracts were examined and discussed in the course of a tour in 1933. The main climatic climax type was considered to be the form to be seen in the unworked forests near Mainimukh with *Dipterocarpus pilosus* and *Buchanania lancaefolia* and it was thought that ancient shifting cultivation is the most probable explanation of most of the inferior types which appear to differ in growing stock rather than in climate and soil.

The *garjan* forests call for separation as a sub-type the status of which demands further study. It is undoubtedly a less mesophytic form than the tropical evergreen, but may be conditioned by a drier climate, drier soil, or by biotic factors including fire ; probably all three come into play separately or together in different localities, but there are indications that the most logical course would be to consider these forests as belonging to a semi-evergreen type, one step in the xerophytic direction from the tropical evergreen, and owing their prevalence in part to edaphic (physiographic) and biotic factors intensifying any deficiency or unfavourable distribution of rainfall.

In the course of the compilation of new working plans (now in progress) it is to be hoped that further data will be collected and co-ordinated.

Burma.—**Scott** & **Robbin**'s remark in their account of the ground reconnaissance work done as a preliminary to the aerial reconnaissance made in 1925 in S. Tenasserim, that the sub-types of the evergreen forest are legion, but the two chief are " mixed evergreen " and " Kanyin forest " (*Dipterocarpus*), the latter tending to occur more in the broader valleys and lower ground and the former being more typical of the higher slopes. There is usually a dense understorey of bamboo to the *Kanyin* but doubts are suggested as to whether this may not be of secondary origin connected with shifting cultivation. The other types differentiated—small evergreen, sub-evergreen and remnant evergreen are all recognised as of secondary origin. Riverain forest characterised by *Lagerstroemia flos-reginae* and *Hopea odorata* was recognised as a definite seral or edaphic type. In the Myitkyina working plan, **Carroll** emphasises that the evergreen forest is undoubtedly the climatic climax and that all other varieties if protected from fire, etc., unmistakably tend to revert to it. The implication is that various retrogression stages are encountered. No sub-types are indicated but the variation in the undergrowth is commented on—sometimes bamboo and sometimes evergreen.

Andamans.—CHENGAPA has given us a recent description of the Andamans forests. He evidently considers the tropical evergreen to be the climatic climax for the whole area, the other types being only seral stages or edaphic variations. Two sub-types are described, 1, *Low Evergreen* on alluvial soils with *Dipterocarpus alatus, D. pilosus, Artocarpus* and many more or less deciduous species, and, 2, *Hill Evergreen*, the most luxuriant growth of all, with *Dipterocarpus grandiflorus* and *D. pilosus* and almost exclusively evergreen associates. From the distribution it might appear that the first type has not reached the climax, as the soil cannot be mature. The deciduous forests must be a very stable edaphic preclimax as no biotic influences have ever been in play checking progression to the assumed evergreen climax.

Summary.—A useful start has been made on the recognition of sub-types in the West Coast forests and it may be hoped it will lead to a standard classification applicable to the whole strip. Practically nothing has been recorded from the other evergreen regions.

5.—*Natural Regeneration.*

West Coast.—Recent studies have only tended to confirm the earlier observations that whereas locally profuse regeneration of the important species is encountered, there is very little over extensive areas. Thus in the Karian Shola at Mt. Stuart, regeneration of *Hopea* is reported to be abundant in localised patches, that of *Mesua* more evenly distributed but not abundant and that of other valuable species, scanty. The *Hopea* regeneration is under a 5 year tending cycle but it is believed that in the 1933|34 areas none was found to tend. Systematic experiments (E. P. 21|22, 115|116) are in progress to determine the best method of getting up small *Hopea* regeneration, and whether browsing is an important factor (E. P. 120|121).

In Palghat, the excellent regeneration of *Poeciloneuron* is commented on, and with its marked tendency to gregariousness, it is considered that it would be a comparatively easy matter to regenerate it successfully under a shelterwood. *Mesua* regeneration is commented on as deplorably short in all associations except the *Mesua—Calophyllum.* The profusion of *Palaquium* seedlings but lack of saplings and poles except where the canopy is broken is also commented on, though a local exception with conspicuous regeneration is mentioned. *Vateria* also tends to occur gregariously and its regeneration in suitable sites is excellent. The profusion of *Hopea* regeneration round suitable mother trees is well-known.

The proportions of the several girth classes in the Wynaad forests confirm these general observations shewing that neither *Mesua* nor *Calophyllum* can maintain the existing stock of large trees, whilst *Palaquium* undoubtedly can do so, and probably *Vateria* also. There is said to be adequate regeneration of *Mesua* and *Palaquium* in about half the felling gaps of the last three years—coupes. Regeneration of *Dipterocarpus* ordinarily occurs in fair quantity near seed trees.

The tendency during the last quinquennium in the management of these evergreen forests has been to recognise that—as the position was summarised at the last conference—the type cannot regenerate itself as such after any but the lightest fellings. Fellings are so restricted as to prevent the formation of large gaps ; thus in Karian Shola, not more than 3 trees per acre and no two trees within 20 yards of each other may be felled and similarly in Wynaad.

In the gaps any natural regeneration is to be assisted and supplemented by planting as will be described later. Where natural regeneration is profuse, it may be tended by removal of the undergrowth and lower storey trees checking its development, the upper storey being only gradually removed as the saplings respond to the earlier operations. Such work on a 5-year cycle is prescribed for *Hopea* in Karian Shola, has given good results with *Balanocarpus* in Tinnevelly, and has given good results on an experimental scale in Coorg and Malabar. It should be repeated, however, that suitable conditions are relatively rarely met with. Costs need not be high and are put at Rs. 1-8-0 per acre of area actually treated for Karian Shola, whilst in Jalsur E. (S. Malabar) the total cost to the complete removal of the overwood is shewn at Rs. 32 per acre, though here overhasty uncovering *Hopea* regeneration resulted in a lot of *Macaranga, Mallotus* and climbers getting up and requiring repeated cutting back.

An up-to-date report on the results of the work done near Makut should be valuable.

Many experiments have been made since 1925 at Mt. Stuart in the Wynaad aiming at getting natural regeneration by canopy manipulation, with almost no positive results so far though much useful information has been collected incidentally. Long suppressed *Hopea* and *Mesua* saplings seem very slow to respond to tending, perhaps less so in regeneration gaps than under a more uniform high cover.

E. Himalaya.—In Lakhimpur, regeneration of *Dipterocarpus* and *Shorea assamica* is abundant and responds well to opening out. *Mesua* regeneration is also noted as abundant. *Altingia* is rare and seems to require exposed mineral soil. *Artocarpus* regeneration is frequent and comes up even under dense bamboo shade. The position is summarised to the effect that though the number of seedlings appears satisfactory, conditions are such that very few survive owing to the prevalence and vigour of climbers and soft wooded species ; in the better areas, however, the numbers are being maintained except for the *Dipterocarpus* which is losing ground.

As noted before, the success with aided natural regeneration of *Terminalia myriocarpa* in the Sadiya division, has been obtained in a different type of forest, though one where tropical evergreen is probably the climatic climax. The need of exposed soil for good results may be noted, and there seems no reason why several successive crops with *T. myriocarpa* as the dominant species should not be grown on these soils, progression being checked by the method of treatment.

Sylhet.—No new information. The success attending the freeing of regeneration of *Dipterocarpus* round mother trees may be noted (De), but once again such good patches are relatively scarce. More information must have been collected for the new Cachar working plan but is not available.

Chittagong and Arakan.—Useful experimental work has been done in the Chittagong and Chittagong Hill Tract divisions. In the latter, regeneration of *Dipterocarpus, Dichopsis* and *Artocarpus* is definitely abundant, and that of *Mesua* and *Calophyllum* is present in fair amount. A series of plots was laid out in 1930 and 1931 to find a method of removing the overwood such that satisfactory development of this advance growth would result. At present the indications are fairly definite that the correct procedure is to lighten the canopy over regeneration by stages from below upwards ; in this way the existing weed growth is not unduly stimulated and light demanding species do not invade the area, whilst the tree seedlings and saplings respond and can be got into a condition when they can compete with the heavy weed growth which is the inevitable consequence of opening up the higher canopy layers by commercial fellings. Regeneration work accordingly should precede exploitation fellings. Very light scattered selection fellings are not here considered a practical proposition.

Burma.—Experiments have been in progress since 1922 to study the effects of canopy manipulation and burning on natural regeneration of *Dipterocarpus turbinatus* in Katha division (E. P. 1-6) and show that regeneration is best where seedbearers were left and the undergrowth burnt. High shade does not seem to have much effect on the height growth, but unless low shade is eliminated, little progress is made and the mortality of seedlings is heavy. These plots were started by broad-casting 5000 seed in each (one acre) and the best plot after 9 monsoons had 186 saplings over 6 ft. high, 58 of them over 15 ft. high. It is interesting to note that the plot in which the seed was sown under a heavy secondary growth (*ponzo*) without burning takes second place, with 112 and 62 saplings over 6 ft. and 15 ft. respectively. It should be however said that teak is here associated with the *garjan* so that we are probably not dealing with climax rain forest.

In S. Toungoo injured saplings of this species (or ? *D. alatus*) coppiced very well after being cut back.

Andamans.—The experiments and results recorded deal mainly with the deciduous and semideciduous forests but include evergreen patches in these types and the alluvial sub-evergreen forests in which *Dipterocarpus alatus, D. pilosus, Terminalia bialata, T. procera, Pterocarpus dalbergioides*, etc., predominate. The hill evergreen which we have taken to be the climatic climax has not yet been tackled. It is claimed that natural regeneration of the valuable deciduous and semideciduous species, as well as some *garjan*, can be induced and established by removing the undergrowth completely, raising the canopy to 60 ft., burning the slash if necessary, and weeding constantly. It is admitted that further study is required for the *garjan* which is fortunately immune from browsing by deer but suffers badly from destruction of the seed crop by paroquets. In one experiment on 20 acres of well drained alluvium at Bajalungta with *garjan* predominating, good regeneration including *garjan* has come up after fairly heavy logging followed the same year by cutting all undergrowth to 20 ft., and judging from an adjoining older plot, it can be expected to respond well to raising the canopy to 40 ft. with weeding in the second season and again to 60 ft. or 80 ft. within another year but it remains to be seen how the real evergreens respond.

Malaya.—The conclusions reached by Blandford (*loc. cit.* page 394) as to the light thrown on the subject by experience in the Federated Malay States are :—

(1) The overwood of valuable timber trees should not be felled until the fellings in the underwood have induced regeneration.

(2) Reproduction of most of the evergreen species (especially *Dipterocarpus*) requires considerable protection and shade during the period of establishment and the canopy must not be opened too rapidly.

(3) Seed bearers when isolated by removal of the underwood and secondary species deteriorate rapidly and the final felling should not be too long delayed.

Three fellings are usually done ; the first takes out the lower canopy inferior trees to 24 ins. girth round seed bearers of the important species making gaps not exceeding 30-40 ft. diameter ; and it is immediately followed by a cleaning ; the second some 4 years later takes out the larger trees of inferior species and inferior trees of good species over regeneration, and is also followed by a thorough cleaning of the regeneration ; the final felling takes the valuable trees down to the prescribed " selection " limits (which are lower than in India), and it may be made after 2 years, or later if regeneration is not complete ; the next year there is a final cleaning and thinning. Costs are about Rs. 28 per acre and excellent results have been obtained.

Dipterocarps greatly predominate in these forests—*Shorea, Balanocarpus, Dipterocarpus, Dryobalanops*, etc. ; *Mesua* occurs and many non-Indian timbers.

Summary.—In most tropical evergreen forests, good patches of regeneration can be found apparently ready to respond to any opening in the canopy above them, but such patches are generally too few and too localised to suffice for normal regeneration. The chief species of which such patches are found are the Dipterocarps (especially *Hopea*), *Cullenia*, and *Palaquium*. Regeneration between these patches and of other important species such as *Mesua* and *Calophyllum* is commonly very inadequate even though, as for the last named, seed production and germination may be copious, and even though some such as *Dipterocarpus* spp. and *Artocarpus* spp. persist with a definite leading shoot for a long time under heavy shade. Heavy fellings in the overwood result in so strong a response in the weed and climber growth that such regeneration as does exist is smothered, but prompt clearing of the undergrowth is reported in the Andamans to result in copious seedling recruitment (mainly of deciduous species) which can be established by further clearing and raising the canopy annually for a few years and at one third the cost (Rs. 23 in the first year only) of a plantation. It is now the general experience that effective clearing of the undergrowth and raising the canopy from below results in considerable response by existing regeneration and further recruitment, without too great a relative response in the weed and climber growth. Requirements as to the time table for further weedings, raising the canopy and final fellings have still to be determined ; they probably vary considerably with species and locality and the three years asked for in the Andamans is probably a minimum unlikely to hold elsewhere.

The outstanding subjects for research are now the determination of this time table for each local type and the best means of supplementing existing regeneration where insufficient or when an expected seeding fails. Methods of assessing progress in regeneration require standardisation.

6.—*Artificial Regeneration.*

West Coast.—Attention has been concentrated during the last few years to the artificial regeneration of relatively small felling gaps where natural regeneration is absent or inadequate and experiments of this nature are in progress in South Coimbatore, Wynaad, and Travancore.

In Karian Shola, in 1930, unsaleable species were girdled over plots about 50 ft. × 50 ft. and the undergrowth, mainly *Strobilanthes kunthianus*, was cleared (not burnt) and *Acrocarpus, Hardwickia, Palaquium, Vateria* and *Gluta* planted out. Annual weedings have been done and there has been a complete change to short grasses, *Ageratum, Solanum*, etc., but the result is a failure. There are indications that browsing by game is largely responsible for this but fencing is obviously impossible. A repetition in 1933 using *Artocarpus hirsuta* and *Swietenia* looks to be following the same course, but the success and immunity to browsing of a small number of *Araucaria cunninghamii* is noteworthy.

In the Shendurny forests in Travancore, in accordance with a working plan prescription, felling gaps have been planted up with natural transplants, mostly *Hopea*, but very little appears to have resulted, as the gaps fill with quick growing *Macaranga* and *Trema* and a mass of climbers smothers the plants despite a limited amount of cleaning.

In the Wynaad, stump planting of *Artocarpus hirsuta* in 1932 and 1933 in small felling gaps has been fairly successful though browsing damage is considerable. The working plan claims good results from dibbling seed of *Mesua, Dysoxylum* and *Artocarpus*, but apparently prematurely as they cannot now be exhibited. In each gap a square of 25 plants 6 ft. × 6 ft. is being put out, occupying approximately 1|50 acre and costing about Re. 1 per acre, as compared with annas 8 per gap for tending natural regeneration.

At Karian Shola and Chandanothode, systematic experimental work has been in progress the last two years to determine the most suitable nursery and planting out methods for the species of the evergreen forest. The planting out work is being done in the natural forest after cutting back the undergrowth to varying heights and it is already clear that the first attempts removing the canopy only to 10 ft. — 20 ft. left far too much shade and later work is being done with lighter degrees of overwood. The experiments deal with best size of entire or stumped transplant, soil preparation, weeding, date of planting, etc. Date of planting seems particularly important, late August being definitely the best season, earlier work suffering from excess moisture. It will require several years more to complete these investigations as getting a good start is only one step, the greater problem being still how to get established seedlings to grow up and take their place in the upper canopy.

AIYAR collects the available information on the artificial regeneration of the chief species and the following points may be noted though very few of the observations seem to cover more than the first year or two and so are far from conclusive. *Mesua* can be successfully dibbled or notched using germinating seed, but requires to be protected or hidden from vermin : it can also be transplanted under a complete top canopy after clearing the undergrowth. *Palaquium* can be patch sown like *Mesua* (Tinnevelly) or transplanted. An up-to-date summary of the Tinnevelly results should be generally useful.

Acrocarpus has been a favourite species to try in all these experiments, mainly as it appears naturally in felled over evergreen forests and growing very rapidly at first makes a good show. Experience has however indicated that it is very unlikely to be of much value in regenerating the evergreen forest, for a variety of reasons of which its palatability to game is alone sufficient to rule it out..

The extensive and successful under planting and sowing of *Hopea* in Malabar and S. Kanara must be mentioned again, but the forests where it has done well are largely or entirely deciduous in the top canopy (*Terminalia paniculata*, *T. crenulata, Dillenia pentagyna,* etc.) though much of the undergrowth is evergreen. It is considered that this forest is secondary to evergreen and is now progressing once more to the climax type under protection ; *Hopea* would naturally find a place in the climax and conditions are favourable for its artificial introduction. Sowings have been found easier than planting, more reliable and cheaper, in fact locally good results have been obtained by broadcasting the seed with no other work at all. Growth is slow rarely averaging over a foot a year for the first 10—15 years, and experience has shown that the overhead cover should not be appreciably lightened during this period though gradual removal of the lower middle storey is beneficial. Where the forest is already more evergreen, the results of such work are much less satisfactory and it is difficult to keep the young *Hopea* free.

At various times and places, teak has been planted on clearfelled areas where the climax type must be tropical evergreen even if the forest cleared was actually more or less deciduous. There is no doubt that teak can make a good start, even an exceptionally good one, in such places, but more and more instances are to hand that it cannot maintain its early promise and often falls off after even only a few years. At the same time, it is true that locally quite fair teak plantations have been raised in such sites (*e.g.*, Parappa) particularly on light soils. *Swietenia macrophylla* has also been successfully grown in several places and will have to be kept in mind, though it also seems more suited to the sub-evergreen or moist deciduous type.

E. Himalaya.—Hitherto " experimental planting of slow growing shade bearing species has not given results commensurate with the expense involved " (ROWBOTHAM, 1931). *Altingia* can be planted in the open and if kept weeded will reach 3 ft. and 8 ft. in 1st and 2nd year ; it also grows well under *Tephrosia candida*. *Artocarpus chaplasha* is best sown direct and grows rapidly (6 ft. a year in the open) provided it is well weeded as it is easily suppressed and killed by heavy grass. *Phoebe hainesiana* is best grown under a shelter wood or *Tephrosia* but only grows about 1 ft. a year. *Talauma* and *Michelia oblonga* are best transplanted ; and they grow 4 ft.—5 ft. a year and can be raised either in the open or under a canopy or with a cover crop.

Very good results have been obtained with dense strip sowings of *Terminalia myriocarpa* and *Lagerstroemia flos-reginae* in the sub-evergreen or moist deciduous forests of U. Assam, and promising results have been obtained by dibbling seed of *Artocarpus chaplasha* and *Mesua* in the interlines when the *Terminalia* canopy has lifted to 20 ft. or so, and it is suggested that *Cinnamomum, Michelia* and *Talauma* could be introduced in the same way. A later report on this work is needed.

Chittagong and Arakan.—In two localities in Chittagong, quite good results have recently been obtained by notching seed of *Dipterocarpus turbinatus* under a relatively light high canopy after cutting back the lower shade. Practically full stocking has been obtained at small cost and early development is satisfactory. Actually the overwood species are *D. costatus* and *D. pilosus* and these species have been tried in the same way with little success owing primarily to the difficulty of getting sound seed (Contrast success of Burma broadcasting experiments).

The further development of these experimental plots will be watched with interest.

The line of investigation which is showing much greater promise is clearfelling followed by *taungya* plantations using *Tephrosia* to keep out harmful weeds (especially *Eupatorium* which is rampart in the district), and to provide the necessary soil cover and shade to the young evergreens. Complete success can be claimed for work of this kind with *Dipterocarpus turbinatus*, and there is ample evidence that *Artocarpus chaplasha* is equally amenable provided there are no wild elephants. Experiments with *Dichopsis* (*Palaquium*) have started quite well and promise success, and *Eugenia grandis* is also appearing likely to succeed. *Hopea* is more difficult owing to its slowness in closing up but perhaps only needs a modified technique. The most suitable time of introduction of the and its subsequent handling with a view to keeping down costs and the time table to fit in with the other demands on the cultivators' time, have yet to be finally decided and of course other modifications may be found advisable as experience is gained, but a practicable method of regenerating some of the important evergreen species has been found. Experiments are also in progress with mixtures of species such as *Dipterocarpus turbinatus* with *Dichopsis* and also utilising *Gmelina* or *Lagerstroemia* in alternate lines as a nurse crop possibly contributing a few scattered trees to the final crop but handled entirely in the interests of the evergreens which usually means quite early cutting back. Underplanting *Gmelina* and teak crops with *garjans* and *Dichopsis* has also been tried not altogether without success.

Nursery and Experimental Garden experiments have been in progress several years now with other important evergreen species such as *Mesua, Lophopetalum, Calophyllum*, etc.

Burma.—No work on this subject appears to have been done of late.

Andamans.—CHENGAPA has given an account of past attempts at artificial regeneration. The earlier work was done (on a fairly extensive scale) after clear felling and burning, with the deciduous species, varying degrees of success being attained. It should be noted that there is some quite fair teak (1883-89) on *padauk* soils, but the plantations on the evergreen sites (alluvial or hill) after a spectacular start have fallen off badly as elsewhere ; the way *padauk* catches up and passes the teak is striking and rules out a mixed plantation. *Garjan* is noted as among the most refractory species and there is nothing to show for the attempts at artificial regeneration. *Artocarpus chaplasha* sown in 1919, 1921 made a good start but has been ruined by a borer and timber elephants. *Planchonia* broadcast in strips in 1921 on a clear felled area of hill evergreen, also started well with good germination and a height of 12 ins. in 3 months but failed owing to subsequent neglect. *Canarium euphyllum* has been tried but its technique is evidently not yet understood ; it is badly browsed. *Terminalia bialata* and *T. manii* would obviously present no special difficulties in plantation after clear felling or under light shade but also give profuse natural regeneration ; the former reaches 7 ft.—8 ft. in 12 months. These latter species are not however evergreens and it is evident that most of the work done concerns the deciduous forests.

Other countries.—No new information has been received.

Summary.—In localities where climatic or soil conditions approach the drier limit for an evergreen climax, clear felling and planting, with or without *taungya* crops, with the species of the moist deciduous forest—which is often already in possession of the ground from biotic influences—is a perfectly feasible proposition and has been successfully done in most regions concerned. Teak has naturally been the chief species used, but examples exist for *Pterocarpus, Terminalia* spp., *Albizzia, Lagerstroemia flos-reginae*, etc. The exotic *Swietenia* has also done well in several places. In secondary deciduous forest with a definitely wet climate, teak starts well, but does not continue satisfactorily and the same appears true for relatively recent alluvial soils which have not reached the evergreen climatic climax. Pronounced success has been obtained in the latter type in Upper Assam with dense line sowings of some of the species mentioned.

Underplanting and sowing of *Hopea* has been done successfully on a large scale in secondary deciduous forest reverting to evergreen with a heavy rainfall and protection.

Clearfelling and *taungya* plantation with evergreen *Dipterocarpus* and *Artocarpus* has been successfully effected in S. Bengal with the help of a *Tephrosia* cover crop and *Eugenia, Dichopsis* and *Hopea* are promising under similar conditions ; dense strip sowings seem to be required. *Gmelina* has also been used as a temporary nurse crop and underplanting *Gmelina* with *Dipterocarpus pilosus* and *D. turbinatus* can be done.

Planting up minor gaps made by selection fellings or removal of valueless species has been tried in S. India fairly extensively, so far without much success and systematic research is in progress aiming at establishing artificial regeneration of evergreen species before making fellings in the main canopy, after which the technique would be as for natural regeneration.

7.—*Proposals for future work.*

There is a feeling that there is quite sufficient overlap in conditions between provinces to render organised co-operation desirable for maximum results from the limited staff, time and money which can be devoted to the problems of the tropical evergreen forest.

The first step is, as indicated in the 1929 Resolution, a clear decision as to what shall be considered as constituting tropical evergreen (rain) forest and what sub-types require recognition for practical purposes. It is hoped that the 1934 Conference will be able to reach an agreement on this point, starting with the Central Silviculturist's draft.

The main aspects of the research work required are summarised in the following sections :—

(A) *Natural Regeneration*—

1. Collection of data concerning frequency of seed years, extent and mode of dispersal from seed trees, etc.
2. Determination of conditions favourable for germination and seedling recruitment.
3. Determination of the best procedure for establishing small seedling regeneration or recruitment, with respect to manipulation of the several canopy layers including ground weed growth, considering both time sequence and intensity—
    (*a*) Prior to the major fellings (under shelterwood).
    (*b*) With and subsequent to the major fellings (in felling gaps).

(B) *Artificial Regeneration*—

4. Artificial regeneration as under 3.
5. Artificial regeneration in larger clearings.
    (*a*) Departmental plantations.
    (*b*) Taungya plantations.

The following notes are added in amplification of the above outline.

A.—*Natural Regeneration*—

1. Data on seeding and seed dispersal are best collected by keeping under observation a small number of good seed trees, say 6 to 10, growing under the natural range of conditions.

2. Conditions favourable to germination and seedling recruitment can be tentatively determined by direct observation in the forest. This study is rarely pursued as far as is necessary, for it is quite inadequate to record conditions prevailing on a few sites with good regeneration. It calls for a systematic tabulation of the factors most probably involved, for the vicinity of a number of seed trees growing under different conditions (or for a series of representative spots for diffuse regeneration) and the determination of the highest common factor associated with satisfactory recruitment. It will still be possible that this factor requires further analysis. Thus failure might always be found associated with a particular form of high canopy and a particular ground cover but only the latter might be the real cause. The field can be greatly narrowed in this way and the tentative deductions tested by following developments under the previous head, introducing if necessary the conditions under which success is predicted. It must be remembered that deductions as to what constitute favourable conditions, from older regeneration of unknown history, is very risky.

3 (*a*). When small regeneration is present on the ground either naturally or as the result of operations carried out on information acquired under 1 and 2 above, the much more difficult operation, that of getting it up into the canopy, remains to be done. Existing experience all points in the one direction that the over head canopy must be lightened from below upwards, and where practical conditions allow, investigations may safely be based on this premises. Practical or economic considerations are however of great importance and vary much with locality. Sometimes fuel is saleable which is a great help ; sometimes small timber of second class species and poles, *i.e.*, an appreciable part of the middle storey, can be disposed of, which widens possibilities ; but often, nothing except large timber of a few selected trees will pay for extraction, and any other

fellings must be done at direct cost and may involve destruction of growing stock which has a potential value for the future. The existing proportions of such timber trees both of exploitable size and smaller, is also an important factor in determining what is practicable.

The general considerations given for research on natural regeneration in the *Experimental* Manual, pages 107-117, apply, though details require adapting to this particular problem. Experimental Plots involving canopy manipulation must be relatively large, or rather they must be provided with a large surround similarly treated, to ensure that the intended light conditions really do prevail in the plot proper. In the present case, they must also be large enough to permit of later sub-division, since the time when subsequent operations are carried out is known to be important and different combinations will have to be tested. And as tropical evergreen forest varies more than any other, adequate size is again essential to give representative conditions and to permit of finding comparable sub-plots for comparative studies. Assessment of regeneration and its progress is most important, and methods must be adapted to each series of plots. Full enumeration will be as misleading as ever, and enumeration of stocked squares (*Exp. Man.* page 110) will still usually be the best method, but the squares may often be better distributed in one or more lines or strips across the plot than in a compact indicator plot. The seedlings should usually be differentiated into say three size classes such as 0-3 ft., 3ft.—9 ft. and 9 ft.—15 ft. in height, and some 50 seedlings in each class are needed in each plot. If the individual history of this sort of number of seedlings can be followed in relation to growing conditions (with a record on Exp. Plot Form No. 6), valuable data are likely to be obtained.

As mentioned, the time table according to which operations are carried out, is known to be of great importance, but to a useful extent is indicated by the growth of the seedlings. If a significant lightening of the lower canopy results in a prompt response, the indications are that further lightening should follow soon, whereas if the response is slow, there is a risk that further fellings would be dangerous. With regard to undergrowth, also, treatment must vary according to its nature and reaction to cutting back : thus *Strobilanthes kunthii* is easily dealt with by cutting back, whereas certain other species can only be got rid of by uprooting. Repetition of cutting back or uprooting may be much more effective if done with a short interval than if left until vigour has been regained.

It cannot be said that the effect of burning felling debris or cut and dried undergrowth in evergreen forest has been exhaustively studied, but as a rule it is impracticable, and such evidence as we have (Madras and South Bengal) indicates that it is not advisable.

3 (*b*). The study of establishment of natural regeneration in felling gaps is to this extent a simpler problem than the last in that canopy conditions are already determined, though conceivably small gaps might require enlargement by felling or girdling useless trees on their periphery. The question of burning the felling debris arises, and will usually be answered in the negative as evergreen natural regeneration is fire tender and ordinarily every seedling is valuable, but the debris increases the difficulty from weeds and climbers and may require piling even if not for burning.

It is usually necessary to determine :—

1. What amount of regeneration is necessary to ensure that the gap will be restocked.
2. What tending is necessary, particularly during the first year or two after felling.
3. The effect of the size of the gap.
4. Rates of growth and hence duration of tending operations.

The chief difficulty is to ensure comparability between differently treated gaps. To overcome this, it is suggested that regeneration of the desired species should be staked in a number of typical gaps and the gaps divided transversely to their long axis into 6 or 8 sections with roughly equal numbers of seedlings, and the sections allotted to treatments ABBAAB. . . . As the influence of the gap extends appreciably into the surrounding forest, the treatment should be likewise extended. The individual history of a number of seedlings as suggested under the previous head will certainly be worth recording though it takes time. Several species can be studied in one gap, but the lay out must treat one as the chief.

Treatments must remain cheap and an important practical point is that they should be finished in as short a period as possible. It is also advisable to avoid rendering the regeneration over conspicuous and therefore extra liable to damage by game. It may therefore be advisable to postpone cleanings till there is adequate natural regrowth to hide the seedlings and to remove only such of it as is directly harmful.

B.—*Artificial Regeneration*—

4 (*a*). There is at present very little information about artificial regeneration of evergreens under an evergreen shelterwood, though in many forests natural regeneration is deficient and often the seed trees of desired species are too few or too localised (*e.g., Hopea* in Karian Shola). The advantages of having or getting natural regeneration are self evident, but it is probable that some artificial supplementing will always be required. At present, investigations should largely be limited to the research stages (*Exp. Manual* page 11) in the evergreen experimental " garden ".

4 (*b*). Artificial regeneration in felling gaps cannot however be put off. On various grounds, it is often essential to continue exploitation fellings even where regeneration is deficient, taking such precautions as are possible to minimise endangering the structure and productivity of the forest—such cautious fellings are actually now in progress in many places as mentioned above. The minimum problem is to get up at least as many valuable trees as were felled—though a case can of course be made out for raising them elsewhere than in the felling gap (see below)—and to do this at an economic cost. The Wynaad procedure of aiming at a compact group in each gap seems a good one from the practical point of view. Such gaps can at most be looked after for 2 or 3 seasons, and thereafter perhaps a cleaning at half time to the next felling, so quick early growth is essential. This pre-supposes an adequate knowledge of the artificial regeneration technique for the species concerned under gap conditions and where this does not exist, it should be acquired by small scale experiments in 2 or 3 typical gaps, fenced if possible and laid out in lines across the long axis of the gap, quite close spacing being permissible and the lines being preferably continued into the edges of the gap.

The question of weeding *versus* browsing will be partly answered by the experiments on natural regeneration.

Dibbling seed is a cheap operation and can be done inconspicuously. I consider it deserves much further trial with *Mesua, Calophyllum* and *Artocarpus,* results being correlated with prevalent weed types. The majority of such experiments in the past has not been properly maintained however they may have started. The success with dibbled *Dipterocarpus* seed in S. Bengal may be mentioned again.

5 (*a*). *Departmental plantations* offer the great advantages of concentrated exploitation and regeneration operations and the impossibility of concealing failure to regenerate. They are open to the silvicultural objections to clear felling with soil exposure and the lack of the shade required by many species of evergreen seedlings. They are open to the management objection of the felling of much immature stock. They are often open to practical objection on account

of difficulty in finding the requisite staff and labour for the plantation and tending work. Finally, they are condemned on aesthetic grounds. The tendency of the times is towards demanding that our evergreen forests should be so managed as to give the full timber outturn they are potentially capable of : if they cannot yield more than a fraction of this, the equivalent of the non-productive proportion should be handed over for more economic uses ; this attitude is likely to intensify with the passage of time, and we have no convincing grounds with which to combat it. The scope for departmental plantations seems to be limited to the determination and demonstration on a strictly restricted scale of practicable methods before attempting work on a larger scale, a working plan scale, with *taungya*. They should be undertaken where good supervision is possible or they will surely fail ; 5—10 acres a year is ample ; costs should be recorded but results should be judged largely independently of cost in this stage ; experiments must be maintained till the tree cover is restored. In other respects, investigations should be on the same lines as for *taungya* next to be considered.

5 (*b*). *Taungya plantations*.—The objections to the sudden and full exposure of tropical forest soils by clear felling, with the aggravating addition of a hot burn, the removal of one or more agricultural crops and the maintenance of the soil in a loose easily eroded condition, cannot be disputed in kind, but they can in extent. The physical, chemical and biological conditions of the soil are all very greatly altered in a generally unfavourable direction and considerable soil erosion is inevitable, but we have to determine whether if we minimise this deterioration as far as possible, it will be compensated by the ultimate economic gain from the substitution of a new full and regular crop of the most valuable tree species in place of the existing irregular crop in which we have usually but few and scattered trees of value, rarely one tenth of what is possible.

It may be accepted that a complete soil cover must be re-established quickly, such that erosion and further deterioration are checked and the building up processes brought into play again ; also that the new crop with its natural or introduced underwood must be capable of forming a closed crown canopy similar to that destroyed. There is no clear proof of the necessity, but the indications are to the effect that it will be very risky to attempt to restock extensive continuous areas with a single species and that our aim should be to get a fairly mixed crop of the better species, mixed both horizontally and vertically. In particular a good second storey species should be introduced in view of the usual structure of these forests with the top storey trees projecting singly or in groups above the general level ; such a mixture would be *Mesua* or *Dichopsis* with the giant *Dipterocarpus*.

Taungya work cannot satisfactorily be experimented with on a small scale, as the village and its requirements for a period of years is the minimum unit. For this reason, the departmental plantation should if possible precede the establishment of a *taungya* settlement and obviously such a settlement should be of minimum workable size till an acceptable plantation technique has been found. Once a *taungya* village has been settled it is liable to be difficult to get rid of.

The chief differences between the species of the evergreen and moist deciduous types are the need of shade in the early stages and the usually slower growth of the former. It must be noted however, that these differences are not invariably pronounced. Side shade rather than top shade is usually what is required and can be given in *taungya*, whilst some of the evergreens are by no means slow in growth, (*e.g.*, *Artocarpus* spp.). The obvious line of attack is to select a *taungya* crop which will provide the required shade or to make use of a cover or nurse crop. The former course is difficult as the cultivators will only grow the crops they are used to, but the point is worth bearing in mind. The latter course has been adopted with success in S. Bengal using a *Tephrosia candida* cover crop and is under investigation using *Gmelina* as a nurse crop. With *Tephrosia*, the problem is to get it tall enough by the first dry season to give the necessary shade : it has been met by sowing with the last weeding of the paddy in August, resowing as necessary at the time of harvest, but there are practical difficulties in that this makes demands on the cultivator's time when he cannot spare it, and it cannot be said that finality has been reached. It has even been suggested that the weed *Eupatorium* might fulfil the role of cover crop quite well and be no more difficult or expensive to control than the *Tephrosia,* and there may well be something in this, the fact being that we have no experience whatever with cover crops other than *Tephrosia.* Weed growth being exceptionally luxuriant in the type, the early closing of the tree canopy is even more important than usual and not only for the benefit of the soil. There are accordingly definite possibilities in the idea of utilising easily raised quick growing species such as *Gmelina* and some of the naturally growing deciduous colonists, such as *Macaranga,* to restore the cover quickly, to keep down light demanding weeds, and at the same time to permit the evergreens between and beneath them to get well established. This field has hardly been touched yet, but obviously the straight forward plantation work for the evergreens to be grown must be properly worked out as a preliminary.

As regards method of planting, general experience to date favours more or less dense strip sowing as the safest procedure, ensuring the earliest possible closing up and an ample margin of plants to replace chance casualties which with wide staking result in undesirable gaps ; cleaner growth and possibly more rapid height growth also result. For species which on account of short and irregular seed supplies, (*Mesua, Gluta*) or slow early growth, have to be planted out from nursery stock, it will probably be found that they are most effectively introduced in association with such strip sowings of other species. Where a simple two storeyed mixture is in view (*e.g., Dipterocarpus* and *Dichopsis*) alternate strip sowing seems indicated—possibly again with alternate lines of a nurse crop throughout. It is predicted that 3 species mixtures in one form or another are likely to find favour in time, the third (varying from place to place) perhaps in groups among an alternate line mixture of the other two ; or quite possibly the second storey species will be varied in successive lines.

Until we have fuller growth data, an assessment of the relative financial prospects of plantations of the several species which might be grown—actually their number is small—is impossible, and it is more than likely that on most grounds it will be found best to raise most of them together as a mixed crop. This subject has however much more to it in view of the serious doubts entertained in many quarters as to the future of the heavy construction timber demand, and other things being equal, the quick growing easily worked general purposes timber seems the safect proposition for the bulk of the future crop, with a proportionate of the better quality hardwoods for which a continued demand for special purposes can fairly be anticipated.

The same considerations necessitate a decision on the question of what is permissible silviculturally and advisable economically with regard to the intentional displacement of the evergreen forest type by outstandingly good deciduous or semi-deciduous species such as teak and mahogany. It cannot be disputed that in many localities, the effect of clearing the evergreen is such as to alter growth conditions—virtually climate, including the soil—back to those associated with the moist deciduous type : progression to the evergreen climax is slow and for practical purposes could be controlled or ignored with organised management. In such places, we may be justified in intentionally changing the type and we may even be economically wrong if we do not do so. On the other hand, evergreen forests where the climate is well within the tension line dividing the type from the moist deciduous, must be maintained as evergreen unless it can be proved beyond cavil that a departure violating our present knowledge of biological processes, is possible and profitable.

Notes on the above paper.

(*i*) *Assam.—Change in the nomenclature.*—Before discussing the question of regeneration of tropical evergreen forests it is necessary to know what exactly the " tropical evergreen forests " mean.

2. By " tropical evergreen forest " it is perhaps intended to refer to the forest type which represents the climax vegetation under tropical conditions. It is considered that " Mixed forest at the climax stage " will be a better term than " tropical evergreen forests " for such types of vegetation. This may include dry evergreen forests in tropical climates with less rainfall due to the general similarity of the problem of regeneration, but there is no harm in

including them under the same category. The latter type of forests is represented in eastern part of Nowgong where *bonsum* (*Phoebe goalparensis*) is the most commercially important species and the problem of weeds is no less difficult than in Lakhimpur and Sadiya where the climate is much wetter.

3. In the Working Plans of Lakhimpur and Sadiya, a number of forest types has been locally recognized and it has been pointed that the distribution is entirely due to edaphic causes. Out of the many types represented in the same climate, the *hollong-nahor* type in the *hollong* (*Dipterocarpus macrocarpus*) zone and *nahor* (*Mesua ferrea*) type in the *Outenga* zone are the only types of vegetation which represent the climax stages in the same climate but under different soil conditions. The problems of regeneration in these two types are entirely different. In the *nahor* type, *nahor* is gregarious and being a dense shade bearer, establishes itself freely under a dense condition of the canopy. In the *hollong-nahor* type, *nahor* loses its tendency towards gregariousness and the overwood consists of a number of species, each with a distinct habit of its own regarding silvicultural requirements and rates of growth in the seedling stage. In the Surma Valley the climatic conditions are different. Whereas in Upper Assam we have more or less distributed rainfall throughout the year, it is not so in the Surma Valley and there is a pronounced hot season in contrast to the Upper Assam. The above discussion will show that within the same locality no two problems are alike. A warning is therefore necessary that experience in one province should not be applied blind-fold to another without proper realisation of the factors prevalent in the locality under consideration.

4. Of all the types of forests with which I am acquainted, in Upper Assam *hollong-nahor* type is the only one which bears a close resemblance to those that have been discussed in the note of the Central Silviculturist, and subsequent remarks will generally apply to this only. In connection with the work done in Assam so far, reference has been made to *Terminalia myriocarpa* in the note as a species of the tropical evergreen type in Assam but this is not correct. It is a deciduous tree flourishing generally in the most recent alluvium composed of soil rich in silt hardly exceeding 3-ft. in depth with sub-soil composed of river sands.

5. *"Economical aspect of the regeneration technique of the tropical evergreen forests."*—In Assam we recognise that representation of the valuable components in the mixture is the determining factor of the method of regeneration to be employed. Unless at least 40 per cent. of the mixture is marketable and there is a firewood demand to absorb what will be removed in the course of regeneration fellings, there is no justification for the sacrifice of timbers which have a potential value, simply for the sake of getting natural regeneration. It is realised that properties of all timber yielding species have yet to be investigated and what is considered to be useless to-day may be useful to-morrow. In this connection, *bonsum* (*Phoebe goalparensis*) (formerly known as *P. hainesiana*) may be cited as an instance. Before the war the species used to be considered as useless, during the war we were selling the same tree at Rs. 2 per tree, whereas to-day an average tree fetches a revenue of Rs. 60 to Rs. 70 and the stock is very nearly at an end. Where the mixture is deficient in valuable components but there is a firewood demand, we propose clear felling and artificial regeneration. In cases where there is neither a firewood demand nor the proportionate representation of marketable components sufficiently high, our system of management is "compensatory regeneration", *i.e.*, we accept whatever natural regeneration is vouchsafed to us but instead of trying to regenerate scattered gaps caused by fellings, a special accessible blank area is selected where there is a convenient labour supply, and regeneration is carried out on such a scale that the plantations at maturity yield the quantity of valuable timber that has been removed from the forest. The economical aspect of the regeneration technique of evergreen forests does not seem to have been sufficiently stressed in the note compiled by the Central Silviculturist.

6. The policy of Compensatory Regeneration is perhaps revolutionary, but, however repugnant it may be to the forester to have unsightly gaps in his forest, the policy is undoubtedly a sound one economically for Assam wherever there are blank areas in really accessible localities (we have only too many of these) and insufficient labour and funds to fill up both these and the new gaps being formed by exploitation in less accessible sites. The essence of permissible Compensatory Regeneration is that it should cost less to form, be more

convenient to manage and, from its favourable situation, be ultimately more valuable than regeneration formed in the new gap being caused by exploitation.

7. *Natural regeneration.*—Only the accessible portions of the *hollong-nahor* type of forests fulfil the conditions where natural regeneration is considered as economically feasible. Such areas are surrounded by tea gardens where there is a good demand for firewood and the valuable components of the mixture form nearly 40 per cent. The marketable species in this type of forests with their fruiting season are given below.

Hollong—Dipterocarpus macrocarpus—February.
Nahor—Mesua ferrea—September-October.
Amari—Amoora wallichii—July.
Sam—Artocarpus chaplasha—August.
Makai—Shorea assamica—February-March.
Sopa—Magnolia pealina—October.
Manglietia insingis—September-October.
Michelia oblonga—September-October.
M. montana—September-October.
M. mannii—April.

8. It will appear that the fruiting season in the case of most of the species is either premonsoon or postmonsoon. *Terminalia myriocarpa* and *Largestroemia flos-reginae* are not included in the list as these are not typical species of this type of forests though they are important species of the region.

9. In the matter of seed dispersal the birds and water play very important part in the case of species such as *amari*, *sam* and *sopas* of various species. In one instance where the canopy was light and was composed of *Terminalia belerica*, *Castanopsis* spp, *Bombax malabaricum*, *Engelhardtia* spp, etc., there was a good stock of seedlings of *amari* and *sopa* obviously brought in by birds. In the case of *nahor*, the seeds are taken a long way down by water and seedlings of *nahor* can be found in places far away from the mother trees.

10. The light requirements of the various species differ considerably and under a given canopy condition, the reproduction and the rate of growth of the seedlings of different species vary considerably. In the Jeypore Reserve experimental plot where different canopy conditions are well represented ranging from gaps with full overhead light to places with complete canopy, it was found that as a result of cutting of under growth (including a portion of the underwood) and climbers, there is more *nahor* in places where the canopy is closed whereas *hollong*, *sopas*, etc., are more conspicuous in the gaps.

11. With all these diverse conditions regulating the establishment of different species, it is thus likely that the rate at which the overwood is removed will determine the future composition of the mixture. While going through the note of the Central Silviculturist, it struck me that this aspect of the problem has not been emphasised. The note assumes that all the components of the mixture have the same requirements. This may be generally true in the case of the numerically dominant species but from forester's point of view, the treatment should be modified to establish favourable conditions for the valuable components though in most cases they represent a small fraction of the total number of trees found in the mixtures of the tropical evergreen forests. The note adds that "Existing experience all points in the one direction that the overhead canopy must be lifted from below upwards." Such a procedure will only encourage the shade-bearer *nahor* in preference to *hollong*, *sopas* of various species *sam*, etc., which are usually the most valuable components of the mixture. In our opinion, the removal of the overhead canopy should be as rapid as possible consistent with the progress of regeneration and the necessity for keeping down the weeds, and our proposed technique where *nahor* is prevalent and, if encouraged, likely to become the prevailing species, is to keep just enough seed-trees and middle storey stems to reduce weeding costs. A reference to the photograph of *hollong* regeneration in the Barrajan Reserve will show that the species can stand heavy opening out of the canopy and put on the maximum height growth. If the middle storey trees are to be kept, it is only for reducing the weeding costs.

12. In Chittagong and Arakan, it is advocated that regeneration work should precede exploitation work. In this connection it is necessary to consider the extent of damage that might be done to the advance growth thus established by subsequent exploitation fellings and also, whether the damaged seedlings, when cut back, will produce trees free from rot. From our experience in Assam we very much doubt this in the case of soft wooded species, for rot is likely to set in immediately they are cut back. The coppicing power of the seedlings of different species and their resistance to fungus attack should also be investigated along with the experiments carried out on the above line to induce regeneration before coming to a definite conclusion.

13. *Artificial Regeneration.*—From the experience in different provinces it can be definitely said that the success of artificial regeneration is entirely dependent on the choice of species. Artificial regeneration of *Hopea* in Madras is bound to be uneconomic if the species grows only a foot a year for the first 10—15 years. Dense weed growth in the tropical area can be successfully overcome, only if the rapid growing species are selected out of the several components of the mixture which are valuable. In Upper Assam where clear-felling is advocated in the tropical region, *Lagerstroemia flos-reginae* and *Terminalia myriocarpa* are the main species which are generally grown and they put on a height increment of 3 to 5 feet a year. Dense strip sowing is done for these two species where a plentiful supply of seeds is possible. The defects of strip sowing have been recorded in the Sadiya Plan.

14. In the typical evergreen type of forest in Upper Assam, *i.e., hollong-nahor* type, more than 50 per cent. of the area is nothing but old *jhums,* at present covered by bamboos and climbers and artificial regeneration work is confined to such areas. *Terminalia myriocarpa* and *Lagerstroemia flos-reginae* are not indigenous in this type of forests and only the rapid growing valuable species which are found in this type of forest as scattered trees in the open areas are selected for planting. Such species are generally *sopas* (various species of Magnoliaceæ), *Amoora wallichii, Cinnamomum glanduliferum,* etc. The planting of *Artocarpus chaplasha* is ruled out of consideration on account of its palatability to wild elephants. Mixture by patches (about 5 to 10 acres) is advocated. In the case of these species planting is recommended on account of the difficulty of seed collection. Only a beginning has been made on these lines and it is too early to pronounce an opinion on the success of the technique. *Hollong* and *nahor* are the numerically dominant species in the stocked areas but their absence in the blank areas even as scattered trees is very significant. Whether the soil has undergone any fundamental change due to frequent *jhuming* resulting in conditions inimical to the growth of *hollong* and *nahor* has yet to be determined.

15. One thing we are beginning to stress in Assam and that is the advisability of eschewing species that are locally exotic. We find that nearly every thing can be made to grow on our fruitful soil and in our favourable climate, but working round we find that certain localities provide optimum conditions for species that may grow but not to perfection elsewhere. *Terminalia myriocarpa* is at its best in Sadiya, *bonsum* in Nowgong, *sal* in Goalpara and so on, and the endeavour is to stick mainly to these species in the districts in which they really flourish, so far as is consistent with safety. This may seem to be playing for safety or showing lack of enterprise, but in the light of what has happened in the rest of the world from the days of the disastrous Weymouth Pine planting onwards, is the undoubtedly sound, if adventureless, silvicultural policy.

16. *Proposals for future work.*—The following suggestions are made for natural regeneration :—

(1) Data on seeding and seed dispersal.—Birds, and water play a very important part in the matter of seed dispersal of quite a number of our important trees and this fact should not be lost sight of.

(2) Conditions favourable to germination and seedling recruitment.—If the Central Silviculturist will enumerate the likely factors this will be very helpful.

(3) Determination of the best procedure for establishing small seedling regeneration or recruitment, etc.—

(*a*) Prior to main felling.—Reference may be made to my remarks against " Natural regeneration ".

(*b*) With and subsequent to main fellings (in felling gaps).—Under the points for determination, another item should, in my opinion, be added after (3), *i.e.*, the effect of the distance between the gaps.

In Assam, we are of opinion that attempting regeneration of scattered gaps all over the forests is impracticable and in such cases we advocate "compensatory regeneration". Large numbers of scattered gaps cannot be guaranteed the tending they require and without the tending in time, the regeneration will be choked to death by climbers and weeds.

17. *For artificial regeneration,* a note is required on—

4 (*a*) page 150—No comment.

4 (*b*) Artificial regeneration in felling gaps—

Same remarks as under 3 (*b*).

5 (*a*) Departmental plantations—The mixed forests afford a wide range for the choice of species. If the right species is chosen and if artificial regeneration is only undertaken in areas where there is a definite firewood demand, many of the difficulties enumerated under this head will be overcome. As regards the cost, it has yet to be determined if the natural regeneration is ultimately less costly than the plantation. Besides, natural regeneration is only possible in the best stocked areas which hardly cover more than 40 per cent. of the total forest area in a given locality in Assam.

18. The Central Silviculturist suggests the creation of plantations with *hollong* in the overwood and *nahor* in the underwood. On account of the slow growth of the species we are suspicious about the success of *hollong* in Upper Assam and generally advocate plantation of species other than *hollong* and *nahor,* which are indigenous for the type but are generally faster growing than *hollong* and *nahor.* We estimate a rotation of about 200 years in the case of *hollong* but in the case of other species, a full sized tree can be obtained in half the period.

19. The following statements required comment :—

(1) "Species of the evergreen need shade in the early stage and are usually slow growers." This is not true of the components and in Upper Assam we can choose a number of valuable species which do not seem to require shade and are rapid growers. For instance, *Talauma phellocarpa, Michelia oblonga,* etc., grow successfully without shade and put on a height growth of 4 to 5 feet a year. In the Surma Valley where there is a danger of drought a light shade of *Tephrosia* for the first one or two years is all that is necessary.

(2) Suggestion of *Eupatorium* as a cover crop—

Experience in Assam shows that once *Eupatorium* has got a hold, it is extremely difficult to exterminate.

(3) Dense strip sowing to ensure (*a*) early closing up of the canopy, (*b*) replacement of chance casualties, (*c*) cleaner growth, and (*d*) possibly more rapid growth. This is only possible where a cheap, plentiful supply of seed is available. The objections to dense strip sowing have been discussed in the Sadiya Plan.

(4) Regarding the mixed plantation, it is doubtful if mixture by single trees will come to anything. On account of the unequal rate of height growth of different species, such a plantation will ultimately end in a pure crop of the most fast growing species. After sometime the species with slower growth will be badly suppressed and it is doubtful if they will always respond to any subsequent opening up of the canopy made in their interest. The best method of getting the mixture will be by patches of pure plantation of different species—the size of the patches being reduced to the minimum consistent with facilities for future tending. Where simple two storeyed mixture is attempted the lower storey must obviously be a shade bearer which in Upper Assam is *nahor.* This, however, should not be put out simultaneously but introduced

when the canopy formed by the upper storey species has gone up sufficiently high to permit enough diffused light for the healthy growth of the shade-bearing species. Alternate strip method is not likely to be successful as due to the slower growth of the lower storey species, formation of the closed canopy will be delayed which will make the tending expensive.—*C. Purkayastha, Silviculturist.*

(*ii*) *Bengal.*—The description of the Mainimukh forests given in the *Indian Forester* (1934, p. 460—4) is preferred, four canopy tiers being differentiated. The experimental work in the Chittagong Hill Tracts has been carried on on identical lines with that of the Research Branch of the Malay Forest Department, and the same conclusions appear to have been reached.

In contrasting the success of the Burma broadcasting experiments with *garjan*, it should be clear that it has been experimentally proved in Chittagong that unless the undergrowth up to about 20-25 ft. is completely removed and the canopy slightly thinned to let in diffused light, it is impossible to get any real success from supplementing natural regeneration by broadcasting, dibbling, etc. Dibbling (notching) has alone proved successful and the reason is evidently that the majority of *garjan* shed their seeds some time before the break of the rains and if the seed is not buried, it dries up before the radicle can penetrate the soil.—*C. K. Homfray, Silviculturist.*

(*iii*) *Madras.*—In general, natural regeneration of useful species in evergreen forests in Madras is in most places so scattered or in such small localised patches that it is difficult to find enough material to do experiments on, quite apart from finding enough for introducing tending measures on a working plan scale when the experiments had yielded results. (Exceptions are *Palaquium ellipticum* in Wynaad and Palghat, and *Poeciloneuron* in Palghat, neither of which are regarded as valuable timbers, their sale prices being so low that they barely cover the cost of extraction).

Nearly all the Madras evergreens have but a small proportion of useful or accepted timbers to a large proportion of rubbish, and this makes their exploitation difficult and expensive. It appears that concentrated regeneration measures, such as clear felling and regenerating with evergreens under cover crops either with or without taungya is likely to produce a much greater return on the outlay than diffuse regeneration of felling gaps.

Another method, not specifically mentioned in the note by the Central Silviculturist, is concentrated artificial regeneration of evergreen species under shade of existing evergreen forest. Experiments have shown that complete shade, with only the removal of the lowest storey up to 10 or 15 feet is too dense for almost all the species tried. Further experiments are in progress with different degrees of overhead shade for concentrated regeneration, and it is hoped that the best degree of shade for different valuable species will be arrived at in time. The advantages of this method are :—

(1) It is not so drastic as clear felling and does not involve a change in the evergreen nature of the forest.

(2) The concentrated regeneration will be easier and cheaper to tend than scattered regeneration in gaps.

(3) Fencing might be economically possible for species that are browsed—and most of the species we are hoping to establish,—*Artocarpus hirsuta*, *Swietenia macrophylla*, *Dysoxylum malabaricum*, *Acrocarpus fraxinifolius*, *Gluta travancorica* and possibly *Hopea parviflora* are browsed to a greater or less extent.

(4) Instead of replacing selection fellings in the gaps where the trees were removed, the most accessible and easily exploited areas can be intensively regenerated.

The objections to concentrated regeneration in plantations raised by the Central Silviculturist on page 156 paragraph 5 (*a*), can all be overcome. The silvicultural objection to clear-felling with soil exposure and lack of shade will not arise—the felling of immature stock of valuable species does not apply in most Madras evergreens as it is very easy to find extensive areas without any valuable species. The practical difficulty of getting staff and labour for plantations and tending work is countered by the fact that, for the same final outturn of valuable timber, far greater staff and labour would be required for other methods such as establishing and tending scattered gaps or scattered natural regeneration.

In connection with this method of concentrated regeneration under shade, the possibility of introducing a modified form of *taungya* by raising such shade bearing crops as cardamoms is worth considering.

As stated, the tendency of the times is towards demanding that our evergreen forests should be so managed as to give the full timber outturn they are capable of, and it is probable that concentrated artificial regeneration will achieve this more effectively than any other method in forests in which prolific natural regeneration of valuable evergreen species is absent.

A problem which is exercising the minds of those responsible for regenerating evergreen forests in Madras as much as any is the selection of species. Most of the species which appear to be fairly easy to regenerate are of limited value (*e.g., Palaquium, Dysoxylum, Calophyllum, Cullenia, Hardwickia pinnata, Poeciloneuron, Vateria*), and except in unusually favourable circumstances, do not cover the cost of extraction. *Mesua* and *Hopea* are at present valuable for sleepers but it is considered unlikely that wooden sleepers will be in sufficient demand 100 years hence as to make them saleable. *Mesua* is too heavy and cross grained for a general utility timber. The demand for *Hopea* for general purposes is limited practically to the coastal towns of South Kanara. *Gluta travancorica* is a good ornamental timber, but is likely to have a restricted demand. *Artocarpus, Acrocarpus* and *Swietenia macrophylla* are timbers which will probably always find a sale, but the first of these is very susceptible to damage by animals at all stages of its existence. The last two are also susceptible to browsing and are not true evergreens, and in concentrated plantations would change the nature of the forest. Scarcity of seed in most years is a further difficulty with *Acrocarpus*. *Dipterocarpus bourdilloni* is considered a possibility but it is doubtful whether the timber will sell as well as *Hopea*. *Michelia champaca* has been suggested but it is not known on the local markets. There are scarcely any of these species on which one would feel justified in sinking money in regenerating them artificially at considerable expense, *Artocarpus,* mahogany and *Acrocarpus* being possible exceptions, but even these have their objections. Perhaps the best solution would be to ask the Forest Economist to recommend evergreen species of undoubted excellence for general utility purposes and which, if grown so as to produce regular supplies, would find a ready demand in almost any market, and to experiment with these and discover which can be successfully regenerated artificially under evergreen conditions. It appears to be a waste of time and money to experiment with any but the species that are likely to be readily saleable at a profit in the future.—*M. V. Laurie, Silviculturist.*

(*iv*) *Forest Economist, Forest Research Institute.*—With reference to the selection of species for evergreen forests, I am of opinion that the difficulty of utilising the present " useless " trees in evergreen forests will largely disappear with the introduction and extension of preservative treatment in India.

The unpopularity of a large number of such species is due to their being (*i*) refractory to seasoning (cracking, splitting, warping and " movement " in use), or (*ii*) non-durable against the ravages of termites, borers and fungi.

Preservative treatment will remove (*ii*) altogether and will render the most perishable wood as durable as teak if not more so. This is a most important consideration as it immediately opens up a large field for the use of formerly " useless " woods, and turns them into really serviceable timbers for outdoor use, house construction, and superstructures of all kinds.

Apart from this it is however necessary to maintain a supply of higher class timbers for furniture, cabinet making and interior fitments and from a purely utilisation point of view I would suggest the following species as being those for which there will always be a market :—

Artocarpus hirsuta.—A timber which is usually looked upon as the equal of teak. It is durable, steady, and one for which there will always be a ready market.

Swietenia macrophylla.—A first class cabinet wood. Steady and easy to season and a timber which should always command a good sale.

Pentace burmanica.—A most useful timber for many purposes. Usually free from knots and blemishes and easy to work.

Chukrasia tabularis.—An exceptionally steady wood of the mahogany family. Often finely figured. Has the reputation of never giving trouble after it is made up.

Pterocarpus macrocarpus.—An extremely strong durable hard wood of exceptional merit. Very steady and approaches teak in this respect. Is considered to be the best all-round timber next to teak in Burma.

Hopea odorata.—A timber which in Burma is considered unrivalled for boat-building and structural work. It is a very durable and steady wood and owing to its great strength and toughness it is always in demand for railway carriage and wagon work and bridge construction.

Dipterocarpus spp.—The gurjans are usually first class general utility timbers, but they are not very durable. If given preservative treatment they are equal to the best, and treated gurjan in Burma proved to be superior to teak and pyinkado in teredo infested waters.

Hopea parviflora.—Similar to *Hopea odorata*, but much heavier. Very steady and durable, and where great strength is required cannot be bettered.

The above species will give you something to work on. I quite realise there are difficulties about raising crops of some of these species, but from a purely utilasation point of view, they are amongst the timbers which merit earnest consideration.

If a mixture of white " box " woods is required I would suggest *Dysoxylum malabaricum* and *Vateria indica.* Other woods of the same description are *Canarium euphyllum* and *Sideroxylon longepetiolatum*, both common evergreens in the Andamans. The timbers are very useful white woods popular for box making and match manufacture. The last named is an exceptionally fine white wood which should always command a ready market.

Finally, I would suggest that *Xylia dolabriformis* is a tree worthy of introduction if this is possible. The wood is superior to *Xylia xylocarpa,* and in Burma the tree grows to magnificient proportions and the timber is unrivalled for great strength and durability. It is probably the finest sleeper wood in the world.—*H. Trotter.*

(*v*) *Andamans.*—The Central Silviculturist has correctly summarised our position in the silviculture of evergreen forest. We are now tackling *gurjan* especially in the hill evergreen areas and have progressed a little further than appears from Mr. Champion's note. In Kyitaung, a typical hill evergreen area of 75 acres with climatic climax vegetation, and in Guitar Island an area of 10 acres with preclimax vegetation were experimentally treated last year, clearing all undergrowth and raising the canopy to 30 and 40-ft. The recruits with those already on the ground have responded very well to the treatment. Fortunately we generally have a fair amount of *gurjan* advance-growth in nearly all *gurjan* areas sufficient to give us more trees than are available at present if we can only secure their survival.

In Guitar Island due to very heavy felling in the past and consequent difficulty in the subsequent manipulation of the canopy, about 50 per cent. of the seedlings died. There was no advance-growth in the area. Both the areas—particularly Kyitaung—are now well stocked though not to the same extent as that found in deciduous and semi-deciduous areas. The gaps are filled up with other useful species. First weeding has just been done and the canopy is being raised to 60-ft. according to the requirements of the crop.

Though the new crop is nearing completion of its second season and there is every chance of its ultimate success, it is too early to be exposed to public gaze.—*B. S. Chengapa, Assistant Forest Officer.*

(*vi*) *Burma.*—I stand by my remarks in the Myitkyina Working Plan. I have been correctly quoted. As regards the proposals for future work—

(*i*) I suggest that the first thing to be done is to make lists of species of economic value. Only in connection with those should experiments and observations be made.

(*ii*) A point that requires experiment with is the easiest method of destroying unmarketable evergreen in places where it might with advantage be replaced by marketable deciduous species.

In the Shweli (Mongmit division) I have let Kachin taungya-cutters into one or two reserves of the evergreen + a little magnificent teak type in the hope that the resulting fires will kill off the evergreen and let the teak spread and live.—*E. W. Carroll, Conservator of Forests.*

(*vii*) *Coorg.*—(*a*) *Note by Mr. Robinson, former Chief Forest Officer.*—I. The views I held at the end of my time in Coorg were that the forest was built up of a number of distinct types or zones, and that our practical experience of exploitation and regeneration was confined to a comparatively small area, and that therefore conclusions drawn from past work should be applied, even within Coorg, with great caution, and that I was quite unable to suggest that they were applicable to forests outside Coorg.

Since then I have worked in important rain forests in two of the Malabar divisions, without seeing any area comparable with Makut and I realise more than ever the need for caution before applying elsewhere conclusions formed in Coorg.

II. My conclusions, based on a study of such of the felled areas as came up for " rubbish felling " in my time (*i.e.*, the removal of useless pole and tree growth generally 5 years after the timber felling) were that heavy felling in the first instance was in no way a disadvantage, and that no restriction need be placed against the removal of any tree or pole found utilisable, and no advantage was gained by leaving seed bearers. Also that felled over areas get completely overrun with secondary growth such as *Leea sambucina*, without any noticeable quantity of deleterious growths such as creepers, and that this secondary growth serves as a very good cover for the advance and seedling growth of good tree species. Also that the presence of unsaleable trees and poles served little purpose and the sooner they were removed the better. And that by such means it was probable that the felled over area would eventually be found to be stocked with from 300 to 1,500 per acre representatives of the 8 or 9 principal timber species, mixed with but not suffering from a sufficiency of other vegetation to complete the stocking of the ground.

III. I was, as opportunity occurred, applying these conclusions in fellings subsequent to 1925 and the inspections recently made by Mr. Mitchell, Chief Forest Officer, go to show that the regeneration I had observed in the older areas has continued to flourish, and that the regeneration anticipated has been obtained in the later areas.

(*b*) *Note by the Chief Forest Officer.*—The Ghat forests are situated generally on steep hill sides, thickly clad with tree growth from an altitude of some 2,500 feet above sea level down to the streams in the valleys below. The upper parts of these streams are cascades or else their beds are so thickly strewn with boulders as to preclude the possibility of log floating in any systematic manner. At the sea coast there is a market for the timber and the coast towns are obviously the destination to which it should be sent.

Past History.—In 1911 the forests lying to the west of Urti on the main road was a trackless un-inhabitated jungle on difficult steep slopes. Some of the species, for example *poon*, *Artocarpus hirsuta* and *Hopea parviflora* were known to be of value, but the majority were unknown to the coast timber dealers and had the local reputation of being useless. Under the permit system contractors in the past had extracted the more valuable timber from the comparatively accessible slopes above the Barapole river. Slopes within " Elephant haul " of the river have been despoiled to a great extent. Elsewhere there is virgin jungle.

As a result of discussion with Inspector-General, Mr. Tireman, Deputy Conservator of Forests made a cart road from Urti to Sollekolli which is three miles. Later on this was abandoned, its cost having been covered more or less by timber extracted. This method of working was too expensive and the capacity of road being limited, the question of constructing a tramway was considered. Technical advice was obtained. In early 1918 there was a big demand for timber suitable for aeroplane propellers. After discussions the Government of India sanctioned the scheme and the work was started in June 1918. However after the armistice the urgency of the undertaking must have diminished considerably. About 3,000 tons of *Calophyllum* were felled and dragged ready for removal when the tramway was completed. The Inspector-General of Forests remarks in a note " This timber is being felled in any part of the valley from which it can be extracted without too great difficulty and the operation is therefore nothing more than lumbering and is doing no good to the forest. But apart from this I consider that our efforts should now be directed at regenerating the forest properly and at the removal of scattered trees throughout the area, either of *poon* or any other species in particular."

Mr. Bennett estimated that the total area of evergreen forest in Coorg which could be worked was at least, 100,000 acres, *i.e.*, an annual coupe of 650 acres on a rotation of 150 years. Sir G. Hart was of the opinion that timber be extracted departmentally by tramway and floated from the depot to the coast, and that small quantities of unknown timbers should be sent to the coast to test the market. He estimated that average final yield of saleable timber would be about 25 tons per acre.

The estimated cost of the tramway was Rs. 9,47,000.

Calculation of timber yield from Barapole valley.—Total area of valley as accessible is 28,478 acres. Of this 20,241 acres have been stock mapped. The stock map shows 3 qualities of forest and unproductive area.

I class area.—2,700 acres or 13.5 per cent.—Yield 26 tons and over per acre.

II class area.—4,325 acres or 21.5 per cent.—11 to 25 tons per acre.

III class area.—3,224 acres or 16 per cent.—4 to 10 tons per acre.

Unproductive area.—9,992 acres or 49 per cent.

However it must not be forgotten that as floods in 1924 washed away the tramway, these areas will not be so accessible.

Regeneration fellings in Barapole valley during 1919-21.—As prescribed by Inspector-General of Forests in his note, dated the 23rd January 1919, paragraph (*i*) and (*ii*), regeneration fellings, as an experimental measure, were carried over 1,000 acres, in the following five different methods, during 1919-20 :—

(1) *Method of felling.*—Leave second storey and leave 70 to 100 trees per acre in upper storey.

(2) *Method of felling.*—Leave second storey and leave 35 to 48 trees per acre in top storey.

(3 *Method of felling.*—Fell all lower storey trees and leave 35 to 48 trees per acre in upper storey.

(4) *Method of felling.*—Fell all second storey and leave 70 to 100 trees per acre in upper storey.

(5) *Method of felling.*—Fell upper storey and leave lower storey.

During 1920-21 a further 490 acres were under regeneration fellings under method (1). This area was again felled in early 1922 according to a method of modified clear fellings. In this all saleable timber was extracted, whilst useless species and immature poles of good species were left standing. When the young growth in this area is sufficiently developed the procedure was to girdle shade trees both good and bad.

One weeding was done in 1920 over the whole area and wherever necessary a second weeding was also done. In 1921-22 the whole of this 1,400 acres was weeded twice.

Observations for 1920-21 which are mentioned in the Administration Report for 1920-21.—There are, however, better results in the regeneration of valuable species, where the second storey trees were completely removed. The conclusions to be drawn so far from experimental fellings are that 35-48 top storey trees per acre are not too few for regeneration purposes and that the second storey trees should be removed.

An enumeration over ten per cent. plots in each of the five different intensities of fellings above mentioned, revealed the following results :—

I method of felling—2,040 seedlings per acre.

II method of felling—1,750 seedlings per acre.

III method of felling—2,250 seedlings per acre.

IV method of felling—2,830 seedlings per acre.

V method of felling—1,320 seedlings per acre.

Observations in 1921-22 which are mentioned in the Administration Report for 1920-21.—Results of previous years, experimental fellings in the Ghat forests have shown that seedlings over about 4 feet in height do best in full light, whilst plants below 4 feet in height cretainly suffer if exposed to full light, specially so with *Hopea parviflora* which is perhaps the most important species to be encouraged. The method that is to be adopted for future working is to extract saleable timber and leave standing useless species and immature poles of good species. This leaves what is found in practice to be sufficient shade for the young growth. When the latter is sufficiently developed the procedure will probably be to girdle the shade trees both good and bad. This method also is not found to be inconvenient for logging purposes.

Observations on 400 acres where modified clear fellings were carried in 1922-23.—The regeneration is doing very well and we can be satisfied with the method. An enumeration in November 1922 showed 800 to 1,000 seedlings and established young plants of good species per acre. *Hopea parviflora* is the largest ingredient ; at the end of hot weather of 1923, the number of plants surviving was slightly augmented if anything.

Regeneration areas 1919-21 (Consists of 5 sub-coupes).—Sub-coupe 1.—(Inspection on 5th September 1934).—Timber felling leaving second storey and leave 70 to 100 trees per acre in the upper storey.

The natural regeneration is not plentiful and the existing regeneration is mostly under 5 feet. This gives the impression that overhead light is essential to encourage what there is on ground.

The floor is clean and an enumeration gave 30 trees per acre of the first storey. The growth is dense and the canopy is about 0.8. Many big trees must have been removed during the time the tramway was working and this must be the reason for the limited number of trees in the upper storey.

Enumeration on 15th September 1934 gave 700 plants per acre.

Sub-coupe 2.—Timber felling.—Leave second storey and leave 25 to 48 trees in the upper storey per acre.

Here the regeneration is better than in sub-coupe 1. Enumeration on 15th September 1934 gave 870 plants per acre.

There are on an average 30 trees per acre in the upper storey. Regeneration close to tramline is mostly within 5 feet and those higher up are better in height growth.

Sub-coupe 3.—Timber felling.—Fell all lower storey trees and leave 35 to 48 trees per acre in the upper storey.

Here the regeneration is decidedly better. An enumeration on 15th September 1934 gave 1,370 plants per acre.

The floor is clean and there are many trees in the pole stage, both of important and miscellaneous species.

There are on an average 30 trees in the upper storey. Almost pure patches of *Dipterocarpus indicus* in pole stage are seen.

Sub-coupe 4.—Timber felling.—Fell all second storey and leave 70 to 100 trees per acre in the upper storey.

The natural regeneration is plentiful *Dipterocarpus* and *Hardwickia pinnata* are mostly seen and certain amount of over head light is necessary to encourage what there is on the ground.

The floor is clean and there are on an average 30 to 40 trees per acre in the upper storey. Higher up there are many saplings of important species and good patches of *Hopea parviflora, Calophyllum tomentosum, Dipterocarpus indicus,* etc., are seen here and there. Many trees of big size must have been removed during the time the tramway was working and sufficient opening must have been created to have given scope to the development of regeneration on the ground. I saw some beautiful spars of *poon* in this area.

Enumeration on 16th September 1934 gave 850 plants per acre.

Sub-coupe 5.—(Kariahole) Timber felling.—Fell upper storey and leave lower storey.

In the western half the regeneration is good and we have some promising poles of *Artocarpus hirsuta, Hopea parviflora* and *poon.* To the east there is some reed and natural regeneration is not plentiful.

An enumeration on 16th September 1934 gave 560 plants per acre.

1922-25 area.—Sollekolli.—This is an area where a modified clear felling was carried out in 1922 over about 400 acres. A rubbish felling was carried out in 1925. Nothing has been done since.

An enumeration over 5 acres was done in 1929 and 372 seedlings of valuable species were found per acre. On an inspection on 17th September 1934 of this coupe, we saw natural regeneration of *Dipterocarpus indicus, Hopea parviflora* and *Hardwickia pinnata* of 2 feet and over up to poles of 40 feet in height and 12 inches in girth.

The regeneration is very good. On enumeration we got 700 plants per acre and most of these are over 8 feet in height. The floor is clean and some canes, reeds and other useless growth are also found.

However from an inspection of this coupe, one would form an impression that the heavier the fellings the better the natural regeneration of valuable species.

Quantity of timber extracted after 1924.—In 1923-24 an enumeration over Sollekolli and Memonakolli valley was carried out, with a view to provide a 5-year tentative working scheme. On this basis small areas have been selected for exploitation from 1926 onwards and I propose merely to give an account of what was done in these areas and what my impressions were on the inspection of these five year coupes on 15th September 1934 and 16th September 1934.

Urti coupe 1926.—Area 75 acres. Elevation 1,250 feet.—In this area all saleable timber* was extracted in 1923-24 leaving one seed bearer per acre. In 1926, a rubbish felling was done, which consisted in the removal of all useless species. Nothing has been done since then. In 1929 three small plots of 30 cents were selected in different parts of the coupe and a detailed enumeration of valuable species (seedlings, saplings and poles) was made, according to which it was calculated there were 700 seedlings, poles, etc., per acre.

At first one would gather the impression that except for a mature valuable species retained here and there, that a clear felling had almost been done. No middle aged trees are seen in this area and a uniform growth of trees in pole stage is present in the area. There is profuse regeneration of *Hopea parviflora, Dipterocarpus indicus* and the height growth varies from 5 to 15 feet. Regeneration of *Hardwickia pinnata* and *Artocarpus hirsuta* is fairly good and common. *Hopea parviflora* regeneration is scattered throughout and appears dominant.

An enumeration in three plots of 10 cents each carried out on 17th September 1934 and working on a proportionate basis it was calculated there were 400 seedlings, poles, etc., per acre.

Urti coupe 1927.—Area 63 acres.—Elevation 1,200 feet.—In this all saleable species of 4 feet girth and over were cut. Immediately after extraction a rubbish felling was done, *i.e.*, all useless species above 4 feet in girth were removed or girdled and no weeding was done and the area left as it was.

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*Saleable timber includes all valuable species of four feet and over in girth.

21,905 cft. of timber was extracted and an amount of Rs. 4,247 was realised, including the lease amount of Rs. 1,050.

On viewing the area from the opposite slope one would think that a clear felling had been done. Only a few mature trees of valuable species are left here and there. The floor is clean and some canes, *Macaranga* and soft wooded species are seen scattered over the area. The regeneration of *Dipterocarpus indicus* was profuse and that of *Hardwickia pinnata, Artocarpus hirsuta* and *Hopea parviflora* was fairly good. The regeneration of *Hopea parviflora* and *Dipterocarpus indicus* was on average about 12 feet.

There are no trees of middle aged valuable species present in this area and I think either they were removed at the time of working or never existed at all. There are indications that only in natural gaps these middle aged valuable species are found and any natural regeneration on ground is suppressed or stunted by the heavy shade of the trees in the top storey.

Here three plots ten cents each were enumerated and on proportionate basis, 660 plants per acre were found. The height of seedlings, poles, etc., varied from 2 feet up to 40 feet and over. There are some good poles of valuable species over 12-ins. girth in this area. The particulars of enumeration are given in the list enclosed.

Urti coupe 1928.—Area 127 acres.—Elevation 1,200 feet.—(Three patches of 17, 33 and 77 acres).—The same method of felling and treatment as for the 1927 coupe.

In all 56,941 cft. of timber was extracted including 18 *poon* spars and an amount of Rs. 12,096 was realised including the lease amount of Rs. 3,050. The regeneration of *Hopea parviflora, Hardwickia pinnata* and *Dipterocarpus indicus* was abundant and other important species fairly good. Three one square chain plots were laid out in the three different patches and seedlings enumerated. On proportionate basis we calculated 1,220 plants per acre. Seedlings varied in height from 2 feet and over up to poles of 30 feet.

Considering the nature of felling carried out, one would expect to see a thick growth of creepers, canes, etc. But on inspection I found the floor clean and natural regeneration of valuable species very conspicuous.

Urti coupe 1929.—Area 118 acres.—Elevation 1,350 feet.—The method of working and treatment is the same as descrbied for 1927 coupe.

Here 17,645 cft. of timber and 14 *poon* spars were extracted and Rs. 6,453 was realised, which includes the lease amount of Rs. 3,600.

The natural regeneration of *Artocarpus hirsuta, Hopea parviflora, Dipterocarpus indicus* and *Hardwickia pinnata* was profuse. All stages of growth from seedlings 2 feet up to poles over 15 feet high were seen. Regeneration of *Vateria indica* was not seen. Enumeration on 17th September 1934 over 30 cents gave 800 plants on an acre.

The floor is fairly clean and some parts of the area are covered with reeds and canes. *Leea*, etc., are also seen. It is very interesting to see poles of 15-ins. girth and over of *Artocarpus hirsuta, Palaquium ellipticum, Dysoxylum malabaricum* and *Hopea parivflora* throughout this area. The absence of large trees was most noticeable.

Urti coupe 1930—Area 124 acres (in 2 patches of 55 and 69 acres).—Elevation 1,500 feet.—In 1930 all saleable species of 4 feet girth and over were cut. Immediately after extraction a rubbish felling was done over 55 acres, *i.e.*, all useless species above 4 feet in girth removed or girdled. In the 69 acre patch no rubbish felling was done.

An enumeration was done in 1931 over one acre in the 55 acre sub-coupe and 1,277 seedlings, saplings and poles were enumerated.

On 17th September 1934 an enumeration was done in these two different coupes and on a proportionate basis, I calcudated 1,920 plants in the 55 acre patch and 2,170 plants in the 69 acre patch.

An inspection of coupe revealed that the regeneration of all important species was prolific and at all stages up to poles 40 feet high.

In the rubbish felled patch the floor is fairly clean and has only some reed growth. The regeneration of *Hopea* was more noticeable. In the other patch, where no rubbish felling was done the floor was clean and regeneration of *Palaquium ellipticum, Dipterocarpus indicus* and *Calophyllum tomentosum* was very noticeable.

I noticed some climbers, which need cutting down. All the same the regeneration in these two different patches is splendid. This successful regeneration must be due to having carried out rubbish fellings immediately after extraction of timber in the one case and in another to having admitted sufficient light by the opening created by the removal of trees of exploitable size.

In this area 47,586 cft. of timber was extracted and an amount of Rs. 8,926 was realised including Rs. 1,800, the lease amount.

1934 coupe.—Kerti block.—At the last Silvicultural Conference held in 1929 a resolution was passed that till more was known about regeneration of evergreen forests no heavy fellings should be encouraged. However in Coorg we thought it advisable to test the timber market for evergreen species and in 1933 a coupe of 50 acres was selected in Kerti reserve. 592 trees 4 feet and above in girth were marked for felling, but only 257 trees were felled and 379 logs were prepared. Thirty-six trees were found hollow and the rest were left standing as being too big or being unfit for commercial purposes.

The number of gaps created was 126. In June 1934 *Hopea parviflora* seed was dibbled 6-ft. × 6-ft. in each gap, but this has proved a failure. In July natural seedlings of *Hopea* were transplanted into the gaps and an inspection on 9th September 1934 revealed that they were healthy and doing well. In some gaps Burma bamboo cuttings were introduced and in many cases have taken.

On 19th September 1934 a detailed enumeration of natural seedlings was made in each of these gaps and also for ten feet outside.

It is very encouraging to see the regeneration already on ground. Seedlings of *Hopea parviflora, Vateria indica, Hardwickia pinnata* and *Dipterocarpus indicus* are coming up very well and are from 2 feet to 6 feet high and the impression one would form is to concentrate on these saplings for the next two or three years, removing the storey immediately over head.

This coupe has been divided into 5 strips. The gaps have been located on the coupe map and particulars of enumeration will also be noted on the map.

It is now proposed to keep four strips as they are and concentrate on the regeneration in gaps and on their edges. In the other strips a rubbish felling will be done during the year. Certain number of plots will be laid out in these two treatments and the development of regeneration will be watched and compared.

Thalapathi Irpu (Hopea parviflora) area.—Mr. Tireman in 1921 refers to this *Hopea* area of 16 acres in which all trees other than *Hopea* were felled or girdled in 1918. From 1918-23 climber cutting was done every year. I must say the results are most striking as it gives one the impression of a pure plantation of *Hopea.* The average height will be about 60 feet and girth 12-ins. I should imagine a thinning out is required. It is the best regeneration seen so far. During inspection we noticed that *Hopea* 20-ft. high was coming up very well in the Burma bamboo plantation.

General.—It was most noticeable that valuable species 11 feet and above in girth when felled were hollow. (In 1934 coupe 36 trees were found hollow). So in future it is deemed advisable to restrict felling from 6 feet to 10 feet as trees between 4 feet to 6 feet in girth have no commercial value on the coast.

The valuable saleable species are as follows and their present market value is noted against each :—

1. *Vateria indica.*—Market value Rs. 6-0-0 per candy (of 14 cubic feet).
2. *Hopea parviflora.*—Market value Rs. 28-0-0 per candy.
3. *Dipterocarpus indicus.*—Market value Rs. 12-0-0 per candy.

4. *Hardwickia pinnata.*—Market value Rs. 8-0-0 per candy.
5. *Calophyllum tomentosum.*—Market value Rs. 9-0-0 per candy.
6. *Dichopsis elliptica.*—Market value Rs. 10-0-0 per candy.
7. *Artocarpus hirsuta.*—Market value Rs. 25-0-0 per candy.
8. *Artocarpus integrifolia.*—Market value Rs. 30-0-0 per candy.
9. *Mesua ferrea.*—Market value Rs. 12-0-0 per candy.
10. *Poon spars.*—Rs. 30-0-0 to 50-0-0 per candy.
11. *Burma bamboos.*—Rs. 50 per 1,000 bamboos (even now these bamboos can be sold for Rs. 10 per 100 at the site).
12. *Ordinary bamboos.*—Rs. 50 to 100 per 1,000 bamboos.
13. *Reeds.*—(*Ochlandra* spp.).—Rs. 3 per 1,000 reeds.

Conclusion.—By an inspection of the areas worked since 1919, I am inclined to adopt the following system of exploitation in the Coorg evergreen forests.—Trees above 6 feet in girth should be extracted and those above 11 feet, must be girdled or left to die a natural death. 2 to 3 trees per acre can be left in the top storey as seedbearers. Immediately after extraction a rubbish felling, consisting in the removal of all useless species must be done. It is seen from experimental fellings that to promote natural regeneration already existing on the ground the removal of second storey trees is most essential. By adopting the above system, we will be removing many of the second storey trees and sufficient opening will also be created in the top storey. It is important to protect all growth of valuable species of trees below 6 feet in girth, during extraction.—*J. E. M. Mitchell.*

Report of Debate.

Mr. Laurie.—As the ground has been covered so comprehensively by Mr. Champion in his note, I will merely deal with the points discussed in Committee affecting the resolution that I am about to propose. Mr. Champion's note was circulated to all Provincial Silviculturists interested in this subject for comments. Replies were received from Assam, Madras and Bengal. Coorg has sent in a long note on artificial regeneration in that province and the Forest Economist has furnished a useful note on the types of timber that are likely to be of value in the future and should be considered for artificial regeneration operations.

The Resolution passed at the 1929 Conference read as follows :—

> " *Resolved that this Conference draws the attention of Provinces concerned with tropical evergreen forest to the desirability of solving regeneration problems before proceeding with heavy fellings.*
>
> *This Conference generally agrees with the proposals for policy and research in the Central Silviculturist's note.*
>
> *Further it is recognised that results of evergreen research work cannot adequately be expressed without reference to the forest sub-types (within the category ' rainforest ' or ' tropical evergreen '). Local Silviculturists, in consultation with the Central Silviculturist should try to draw up a classification of sub-types.*".

With regard to the first part of this resolution, generally speaking no heavy fellings have taken place in our evergreen forests, and the exceptions to this, namely the clear fellings in Bengal and the heavy fellings in Assam have both been done in conjunction with systems of regeneration that have proved, at any rate in the early stages, to be effective.

The last part of the resolution deals with the question of evergreen sub-types. The necessity of such a sub-division cannot be doubted. This is well illustrated by the case of *sal* where it was found that prescriptions for management and regeneration drawn up for one locality could not be applied to another. To solve these problems a co-operative investigation was undertaken which has resulted in the sub-division of *sal* forests into no less than 13 sub-types for each of which separate suggestions for management, regeneration and research were made. If such a sub-division was necessary in the case of forests of a single species, it can be imagined how much more necessary and how much more difficult the problem of sub-dividing tropical evergreen forest into sub-types for management and research purposes would be.

This question was discussed in committee and Bengal was of opinion that sub-types in their evergreen forest were few and well defined and are easily recognised. In Assam the economically useful evergreen forests appear to consist more or less of a single climax association with *hollong* (*Dipterocarpus macrocarpus*) and *nahor* (*Mesua ferrea*) as the chief species, with seral stages containing more and more *Terminalia myriocarpa* and becoming more and more deciduous the further away from the climax type the forest is, and no special sub-division of climax types is called for.

In South India the position is different. There are a very great number of sub-types, some fairly distinct but often merging imperceptibly one into another. Since the last conference, with one notable exception, very little has been done to elucidate these sub-types. The exception referred to is Mr. Venkateswara Aiyar's attempt at classification of the Palghat evergreen forests. This is mentioned in more detail in Mr. Champion's note, and it is sufficient here to say that it gives us a good example of the lines we should try to work on. The types should however be recognised by the ecologically dominant species regardless of whether they are economically valuable or not. The necessity for this recognition of sub-types in evergreen forest in South India has been agreed to in committee by the delegates from Mysore, Travancore and Madras, and a co-operative investigation appears to be a perfectly practical proposition, and will accordingly be included in the resolution on this item.

Dealing next with the question of natural regeneration, the present position in the different provinces is given in detail in Mr. Champion's note, and need not be repeated here. Generally speaking, in most localities natural regeneration is insufficient for the normal regeneration of the forest with certain exceptions, notably Coorg and some of the *Dipterocarp* forests of North-East India. Where natural regeneration is found the problems are to discover the best ways of inducing it and of getting it up into the top canopy after recruitment has been obtained, and Mr. Champion has made proposals for future work in his report.

As has already been stated, artificial regeneration has frequently to be resorted to. A considerable amount of work has been done since the last conference in determining the best methods of artificially regenerating evergreen forests, and the most outstanding result has been the successful regeneration of clear-felled areas in Bengal using cover crops to give the necessary shade during the extreme youth of the plants. The species with which the most promising results were obtained were *Dipterocarpus turbinatus* and *Artocarpus chaplasha*. In Madras systematic research has been going on to determine the best species and methods for planting in evergreen forests both under complete shade and in gaps, but although a great deal of useful information has been acquired, no completely reliable method of regenerating evergreen forest artificially has yet been discovered. Later work is being directed towards discovering whether successful plantations can be raised under the top canopy after removal of the middle and lower storeys. Artificial regeneration work in other parts of India, notably the Eastern Himalaya and the Andamans has been progressing. Results are described in Mr. Champion's note, and he has summarised the requirements for further investigations under the headings of :—

(1) Determination of the best procedure for establishing artificial regeneration with respect to manipulation of the several canopy layers including ground weed

(*a*) Prior to major fellings under shelter-wood.

(*b*) **With and subsequent to major fellings in filling gaps, and**

(2) Artificial regeneration in larger clearings either in departmental plantations or in *taungya* plantations on the lines initiated in Bengal. These suggestions are amplified in the later paragraphs of Mr. Champion's note, and the economic advantages of regeneration in compact areas, as well as their advantages from the point of view of easier management, are emphasised. Another very strong argument in favour of compact regeneration areas is the possibility of fencing them economically against browsing.

The question of what is permissible silviculturally and economically with regard to the intentional displacement of an evergreen forest type by more valuable deciduous or semi-deciduous species is one on which a policy should be laid down. In many cases it cannot be disputed that the effect of clearing evergreen forest is to alter growth conditions,—both soil and climate, back to those of the moist deciduous type and that in such cases plantations of deciduous or semi-deciduous species may be successful. On the other hand evergreen forests where the climate is well within the tension line dividing the type from the moist deciduous will probably revert to evergreen conditions fairly rapidly whatever species is planted on them and plantations of teak, for instance, in such areas have proved failures. As Mr. Champion says in his note :—" such forest must be maintained as evergreen unless it can be proved beyond cavil that a departure violating our present knowledge of biological processes is possible and profitable."

Regarding selection of species for artificial regeneration of evergreen forest, Mr. Trotter in his note advocates planting timbers that are valuable for general utility purposes in preference to sleeper woods or heavy constructional timbers, as the future of the latter is not so assured.

(The resolution as given above, on page 137 was then proposed.)

Mr. Trotter.—I don't want that remark of Mr. Laurie's to be interpreted to mean that the wooden sleeper has gone. I consider—and I think most people do so now—that the future tendency in India will be towards the preservation of non-durable wood as against the use of well-known durable woods. Wood preservation in America and Europe has now become such a general feature that most industries will not consider any wood that is not treated. There is no doubt that within the next 20 years or so wood preservation will form the main feature of the utilisation of wood in India, and I would like all Silviculturists to keep this note in mind because it will affect choice of species used. It must be remembered that an ordinary non-durable wood of reasonable strength with preservative treatment can be made to become as good as or even better than such timbers as teak, *sal* or *deodar.* A very inferior wood, for instance, which untreated will last 18 months as a sleeper now, can and has already been in the line as a treated sleeper for 22 years in large quantities. That just shows what can be done by preservative treatment and much of this so-called useless wood in the evergreen forest can be turned to as good uses as teak for many purposes. Naturally we cannot foresee what tendency is going to be. Neither I nor anybody else can tell you what timbers are likely to be required in fifty or sixty years' time. All we can do is to go on the general indications that the timbers which India requires now and is likely to require for a number of years are :—

(1) The ordinary commercial woods which are easy to season, whether they are durable or not durable, and

(2) The ordinary white box woods which India requires in very large quantities and at the moment has not got, and is importing in large quantities. The very heavy woods to my mind are on the down grade.

The seasoning quality of the timber is a very important point. It is quite useless to grow timbers that are difficult to season ; nobody will use them. The timbers that should be preferred are those that are easy to season regardless of their durability as I am certain that within the next few years wood preservation will extend all over India.

ITEM 10.

Artificial Regeneration with the Selection System.

In accordance with the resolution passed by the 1929 conference, a further report on the experiments on " gap regeneration " in Madras was submitted by the Silviculturist and circulated to interested provinces (see below). No other papers or notes were received, except for a short comment from Bombay.

The debate was opened by Mr. TREVOR and representatives of Bombay, Burma, Travancore, United Provinces and the Punjab took part. Mr. LAURIE amplified his report with later information collected on recent inspections.

The following resolution was proposed by MR. TREVOR, seconded by MR. RAMIENGAR (Mysore) and passed by the conference.

RESOLUTION ON ITEM 10.

RESOLVED that—

(1) *Special steps to obtain the regeneration of valuable species in the Selection forest are essential.*

(2) *That the investigation of methods of obtaining such regeneration should be continued and that the gap method as already prescribed in Madras Working Plans affords an opportunity for such investigation.*

PAPER.

By M. V. LAURIE, *Silviculturist, Madras.*

General.—Since the last silvicultural conference, the artificial regeneration of gaps in areas of mixed deciduous forest which are worked by selection fellings has become a routine measure in several divisions. After three or four years experience the method has become fairly standardised in some divisions while in others there is still a good deal of experimenting especially with regard to the size of the gaps.

Theory of gap regeneration.—In our better quality mixed deciduous forests natural regeneration of useful species and especially of teak is very scanty, and does not replace a fraction of the timber extracted. In all recent working plans, the best areas of such forest,—that is to say those definitely suitable for planting teak— are demarcated and put into the Clear-Felling Working Circle, for conversion into teak plantations. The remainder of the workable forest is allotted to the Selection-Felling Working Circle and consists of a poorer quality of forest on the whole not considered suitable for clear felling and planting, though there are nearly always small areas of plantable quality which are not sufficiently large to be worth demarcating and putting into the Clear Felling Working Circle.

The theory of gap regeneration is that wherever a tree has been removed, one or possibly more than one tree should be raised artificially in its place, and that once the gap has been stocked artificially the regeneration should be left to itself to fight its way to maturity. The method is intended to be an imitation of Nature's method with the extra help of getting the plants artificially established and tended until they are about two years old. The actual method has diverged from the theoretical idea to a greater or less extent in different divisions, and is carried out as follows :—

Selection of gaps.—A number of factors influence the selection of gaps, and not every gap that is caused by felling a tree is suitable for regeneration. The best size of gap is a disputed question, and gaps, have varied from small holes in the canopy of bamboo forest, about 25 feet square to small " plantationettes " of a half to three quarters of an acre, made by joining up several natural gaps by felling a few trees of useless species which separated them. The standard sized gap in the Wynaad division, where this method has become more regularised than elsewhere is about 50 to 80 feet square and the unit planting area is 5 stakes × 5 stakes spaced 6′ × 6′. If a larger gap is found, two such units and rarely three such units may be planted in this space if there is room. The unit planting area is however never altered and by far the majority of gaps are of only one unit size.

The type of the surrounding forest influences the selection of gaps. Rather open forest with dense *Lantana* undergrowth is considered dangerous as the

Lantana likely to swamp the young plants before they can get clear of it. Gaps in dense bamboo forest are usually too shady, and the hole left by extracting a tree is usually so small that it would close up by the growth of the bamboos in a few years. The nearer the forest is to the quality considered fit for clear-felling and planting the better are the gaps. In poor areas—(*e.g.*, Chedleth Coupe II—an open grassy area, with some poor to fair teak, lanky *Terminalia crenulata, Anogeissus latifolia, Shorea talura, Phyllanthus* and some wild Date palm definitely not fit for clear-felling)—the gaps have given poor early results and are not likely to be a success.

The best gaps are those in well stocked forest of good quality with no bamboos and a light undergrowth, and the hole in the canopy should not be less than about 60 feet square. Natural gaps not caused by actual fellings are utilised where suitable, but on the whole the number of gaps found suitable for regeneration in a coupe is much less than the number of trees removed in selection-fellings.

The question of the best size of gap will be more fully discussed later, but it may be mentioned here that it is expected that a single unit gap (5 stakes square, or 24 feet square planting area), will produce ultimately sometimes one final tree, and very occasionally two—the average being probably about 1.33 trees per gap. A double unit gap would probably produce 3 to 5 final trees.

The actual method of formation is simple and straightforward. Top ends and slash are piled in a low flat pile 3 feet to 5 feet high and covering the whole planting area with a margin of three to six feet all round and is burnt in February or March. A light burn of material thinner than one's arm is found to be just as good as a heavier burn, and the very severe burn obtained from large logs which go on smouldering for several days is found to be definitely harmful. Teak stumps are planted in April. Other species such as *Dalbergia latifolia* and *Pterocarpus marsupium* have been tried round the edges of the gaps, but have not been successful chiefly owing to browsing or to suppression by weeds invading the gaps from outside.

Tending.—Adhering to the theoretical method of small single gaps, the idea is that the beat guard together with one cooly or watcher is able to look after and keep properly weeded about 500 gaps—*i.e.*, 250 first year gaps and 250 second year gaps, and in the Wynaad this has found to be feasible. The Forest Guard looks after his whole beat which may contain as many as 4 years gaps (about 1,000), and he would be there in any case whether there was any gap regeneration going on or not, so his pay is not charged as an overhead against the cost of gap regeneration in the figures given below. Regarding the methods of tending, clean scrapings are done in preference to weed cuttings whenever the weed growth begins to get dense. In the second year climber cutting has also to be done. Conditions vary so much from gap to gap that no standardised weeding technique can be laid down. As a general rule more weeding and tending is required than in pure plantations.

Early results.—Growth varies very greatly in different years' gaps according to the season and the type of forest, but the following figures give an idea of what is attainable in Wynaad division.

Year of planting.	Locality.	Heights in feet in July 1934.		Remarks.
		Maximum.	Average.	
1930 ..	Chedleth Coupe I	18	8	
	Begur Coupe I	12	8	
1931 ..	Chedleth Coupe No. II	8	4	Very bad area.
	Begur Coupe II	18	10	Unusually good area,—much of it fit for clear felling and planting.
1932 ..	Chedleth Coupe I	5	3	
	Begur Coupe I	10	7	
1933 ..	Chedleth Coupe III	12	3	
	Begur Coupe III	15	3	

There are no figures available for Mount Stuart gaps but the growth there is, on the whole, less than in the Wynaad. Stocking is in almost all cases over 90 per cent.

Cost.—In the Wynaad, as already stated, one Forest Guard and one Watcher can look after and tend 250—1st year and 250 second year gaps, after formation. Actually in some years, there have been far fewer gaps made which has made the cost go higher than is necessary. The formation cost and tending in the first year (including the pay of half a watcher) works out at between 12 annas and 1 Rupee per gap, and in the second year to between 4 annas and 6 annas if over 200 gaps are done. The second year costs consist almost entirely of half of the watcher's pay (Rs. 12 per month). A little tending is sometimes done in the third year costing 0 to 2½ annas. The total cost of establishment is, therefore, in the Wynaad, from about Re. 1-2-0 to about Re. 1-8-0 per gap of 25 plants (= 0.0206 acres).

Cost per acre actually regenerated is approximately Rs. 54-8-0 Rs. 72-10-0.

At Mount Stuart it is more difficult to get an idea of the cost on account of the varying size of the gaps, but from counting stakes the following costs were arrived at :—

Year.	Number of gaps.	Total area of gaps acres.	Average area in gap (acres).	First year costs.			Remarks.
				Total.	Cost per gap.	Cost per acre planted.	
				Rs. A. P.	Rs. A. P.	Rs. A. P.	
1931 ..	56	6·5	0·116	761 12 0	13 10 0	117 0 0	Second year costs not reliable.
1932 ..	50	3·7	0·074	116 8 0	2 5 0	44 10 0	Second year costs Rs. 24 = Rs. 6-8-0 per acre.
1933 ..	30	1·01	0·034	61 9 0	2 1 0	61 0 0	
1934 ..	..	6·5	..	300 0 0 approximate estimate.	..	46 0 0	Number of gaps not known.

Second year costs will probably be about Rs. 20 to Rs. 30 per acre, and owing to the bad regrowth of bamboos and *Lantana* in much of the area, tending will probably have to be continued for at least another two years in the smaller gaps and in the worst places. It will be noticed that the average size of gap at Mount Stuart is anything from 1½ times to 5 times the area of the unit gap in the Wynaad and some of the so-called gaps at Mount Stuart are over half an acre in extent and are in fact little plantations.

Future results.—There are some old gaps regenerated in 1917 to 1919 in Begur range in the Wynaad in an area in which bamboos had previously flowered probably about 1914 to 1915. The Central Silviculturist saw some of these gaps when he came down to Madras and was unkind enough to take a photograph of a really bad one in which the *Lantana* had swarmed over the top of the young teak poles and bent them over. Even in that photograph however a straight pole or two are visible and that is all that is aimed at. This work, however, was not quite typical of our present work in that the gaps were of larger extent (1 to 1½ chains square) and frequently merge into one another. The best stems are about 2½ feet in girth and up to about 50 feet high already. This forest is mostly of good quality (though badly overworked) and much of it would be considered fit for clear-felling and planting. *Lantana,* climbers and elephants have done a lot of damage and bamboos are beginning to do a good deal of suppression, but in spite of this a large number of useful poles are on the ground. The District Forest Officer considers that most of the original gaps can still be traced on the ground and that about 75 per cent. of them could be called useful, having one or more straight established trees in them. In the main, this old example of the method is sufficient proof that, *in suitable localities*, gap regeneration is effective in improving the forest.

The opposite is the case however at Mount Stuart, where most of the gaps planted in 1928 and 1929 have suffered from a gregarious bamboo flowering and a consequent inundation of *Lantana* and other climbers, which have swamped them. Very few teak are now to be seen. It appears therefore, that more care must be taken in selecting suitable areas for gap regeneration if success is to be assured.

Financial justification for gap regeneration.—Every tree that is felled in selection fellings yields a profit, after deducing exploitation charges of anything from 2 annas to Re. 1-4-0 per cubic foot or more according to the species and state of the market,—say about Rs. 20 to Rs. 30 per tree on the average (a conservative estimate). Whatever the figure is, this profit must be regarded as a present from Nature as it were, and we are not entitled to pocket it without making quite sure that the trees felled are replaced. This operation, we have shown, costs about Re. 1-4-0 to Rs. 2 per gap, and, in suitable areas, should produce about 1 1|3 trees per gap. It is evident therefore that to replace a tree which will give Rs. 20 to Rs. 30—clear profit on exploitation, an expenditure of about Re. 1 to Re. 1-12-0 only is required. There are, however many fewer gaps than trees felled, but even if the expenditure went up to Rs. 10 or more the operation would be justified in itself,—*provided that*—

(1) The method is successful,

(2) Cheaper or more efficient methods of regenerating the forest cannot be found.

Psychological justification for gap regeneration.—The beat guard who has nothing but protection and collection of grazing revenue to occupy his time soon loses interest in his forest. An operation like gap regeneration where he has to work with his own hands and sees the result of his labours before his eyes is a great stimulus to the subordinate, and gives him a new interest in his work, and in the forest.

Likelihood of ultimate success.—In the paragraph on the financial justification of gap regeneration two provisos were made, one of which was that the method must be succesful. The indications given above are that the method is likely to be successful and to give one and occasionally two trees per gap in suitable areas. Though the method has not been tried long enough to be certain, it looks as though it is likely to be unsuccessful in—

(1) Poor quality areas, which are obviously not fit for teak plantations (*e.g.*, Parts of Coupe II and III Chedleth).

(2) Bad *Lantana* areas with open canopy (*e.g.*, parts of Coupe III Begur).

(3) Bamboo areas, if a flowering is likely to take place within three or four years of formation and also if the bamboo is dense and high so as to over-shadow the gaps (*e.g.*, Mount Stuart 1928-29 gaps and some of the Begur Coupe III experimental gaps in bamboo areas).

(4) Areas with a dense shady underwood up to half or three quarters of the height of the top canopy (*e.g.*, parts of Coupe I Begur, where the plants have grown so spindly that they have fallen over).

The method appears only likely to be successful in areas without much *Lantana* or dense bamboo in well stocked forest of good quality fit for plantations, or of medium quality not quite fit for plantations.

(NOTE.—This would not apply to the Bombay method of large *rabs* which appear to be suited to a poorer quality rather open teak bearing forest. It is only applied to the method of raising teak in small gaps in the canopy, 50 to 60 feet square.)

Summary.—The artificial stocking of felling gaps with teak has proved at any rate in the early stages to be a successful method of regenerating mixed deciduous forests worked by selection fellings, provided that suitable areas are chosen. The limitations of the method as regards suitability of localities are now being recognised, and it is not yet known how the trees will develop in later years under different conditions. Indications are that on the average at least one tree and possibly slightly more will be ultimately obtained per ga in suitable areas, and if this is achieved the method will be financially sound.

* * * * *

Notes.

Bombay (*Gap regeneration*).—The general body of opinion in Bombay is against attempting to form small patches of regeneration in gaps in irregular forest on account partly of the expense and difficulty of maintenance and partly on account of the generally unsatisfactory results obtained. These unsatisfactory results are variously ascribed to root competition, drip and shading, but may also be attributable in many cases to difficulties of maintenance. Cases in which such work has been done in Bombay have been usually with teak, and larger areas amounting to definite plantations appear usually to be more suitable. Experience in Bombay therefore endorses the opinion expressed in the first part of Resolution 10 of the 1929 Conference.—*E. A. Garland, Working Plan Officer.*

Report of Debate.

Mr. Trevor : Gentlemen, I am only opening this debate owing to the unfortunate absence of Mr. Wilson, who should have been here with us this morning, but has had an accident. Since the last silvicultural conference attention has been directed towards methods of maintaining the stock of valuable species under the selection system, and at the very outset I should like to lay it down as an axiom of forest management that no selection system is a system at all unless steps are taken to perpetuate the valuable species growing in the forest. Now what is this method of gap regeneration ? It was started some years ago in the Wynaad by the local staff and is now a prescription of several Madras Working Plans. The theory is that after felling in mixed deciduous forest, suitable areas where there is complete overhead light are selected, the felling slash collected and piled and then burnt and teak planted 6′ × 6′ to the extent of approxmately 25 plants. Tending is carried out by the forest guard for a couple of years and then the plants are left alone. Certain plants in those gaps will survive and thus enrich the mixed nature of the crop. If after each felling cycle such work was carried out, an appreciable amount of teak would be obtained in these mixed forests. From what I have seen of the deciduous forest of Madras both in the Wynaad and in Mount Stuart, I have formed the opinion that there is practically no natural regeneration of teak in the better areas. Natural regeneration of teak is obtained in places generally on the very worst areas where the rainfall is low and where the crop is of a very second grade type. In the better areas visited practically no regeneration of teak was seen. This gap method is only an attempt to perpetuate the growth of teak in such areas, to obtain normal regeneration and a normal distribution of the age classes ; the alternative appears to be to cut the teak now and to leave the future to take care of itself.

Now there is one important matter which has not appeared in any of the notes which have been written on the subject and which I should like to bring to your notice. In years to come, gentlemen, our work will receive a considerable amount of criticism from the Legislative Council and from politicians in general. If we do not maintain our forest estate in good order and if we cannot show that the forest property committed to our charge is being well managed and is producing a reasonable revenue, that property will be taken away from us. There will be numerous arguments, that the land is required for coffee, tea or sugar-cane. There are a hundred and one perfectly good arguments why forest land should be disforested and handed over to private people for growing some other crop. As in other countries of the world, there is likely to be considerable competition in order to get something for nothing out of Government : and if, when a minister puts a question to the head of the department "what good are you doing with such and such a forest ", we have no answer, to my mind it is inevitable that we shall lose that forest. Therefore I would emphasise this point that it is incumbent upon us to make the best use of every acre of reserve forests that we wish to hold. Now you are all aware that it is much easier to grow teak in a plantation than as uneven aged high forest under the selection system—very much easier. But the fact remains that we have thousands of acres both in India and Burma which there can be no question of converting into evenaged high forest. In such areas you may have pockets of land which are suitable to produce high quality teak ; you may have other areas which will not produce teak but will produce other species ; economic conditions may not justify the making of extensive plantations in certain areas. The fact remains, and we shall never get over it, that we have large areas of forest which will always remain under the selection system and I think it is our duty to determine the best method of managing such forests under the selection system. It has been pointed out that on financial grounds and on considerations of forest management it would be simpler, better and cheaper to select a small area out of the annual coupe, plant that up with teak and neglect the rest ; even if that is cheaper, even if for every rupee spent you can produce a little extra volume in that way over the other, I do not agree that it would be a sound policy to allow the whole of the rest of the coupe to be rendered completely unproductive, which is what will happen unless steps are taken to perpetuate the better species. It is perfectly true that these gaps, plant for plant, cost somewhat more than a teak plantation. On the other hand they have the great advantage that the forest guard has something to occupy his time. It is the standard practice that the forest guard, and possibly his friend have to look after the gaps which have been made in the coupe in his beat. He has to plant them up, he has to tend them, he has to look after them, and he is very proud to take any inspection officer round and show him the trees growing in these gaps ; I think this is a very valuable point. I have seen these gaps myself ; I have seen some of the old ones and I have seen some of the later ones, admittedly some of the old ones have been lost ; *Lantana*, wild elephants, and various misfortunes have overcome them, but nevertheless one or more teak have usually carried on and will provide mature trees when in years to come selection felling comes round again. It has been stated that considerations of finance should be held to be of greater importance than other considerations in our work. I have a note here which reads " unfortunately in this materialistic age the sentimental and asthetic justification for gap regeneration will not be allowed to take precedence over the economic and financial arguments in favour of small teak plantations ". I cannot support that statement. I think we have something more to do in this world than to produce large numbers of rupees. The care of the forests of this land has been placed in our charge and our successors in years to come will judge us not by the number of rupees we pay into the treasury but by the conditions of the crops they find growing on the ground. I maintain that it is our duty to do the best we can for every acre of forest we put under the selection system. (General assent was indicated).

Mr. Garland : I do not know whether this will be agreed to but I am speaking for Bombay as a whole regarding this question of gap regeneration. It is rather a question of names. The principle that we should replace in some way or another the timber removed in selection felled areas I think all agree to. But our difficulty is, that as the Divisional Forest Officer and everybody else moves on very rapidly, the small gap gets lost, but if it can be extended and recorded as a small plantation then it has some official status and will receive some attention as such. The attention may be only at long intervals but it does get some chance of repaying in money what has been spent on it. In other words there is something in the argument that if it cost nothing a planted up gap is better than nothing at all, but that if you are going to spend money on it it is better to enlarge it, even slightly, to the status of a plantation.

Mr. Laurie : There are certain restrictions to the method of gap regeneration that we are beginning to appreciate. The original idea was that we should have small gaps roughly about 50 feet square and that the actual planting in the middle should be about 25 feet sqare, and that is the unit we should like to consider as a gap. Now it is very evident that the bigger the gap the better the plants in it grow, for root competition, shade, and numerous other factors come into play. Another point is that we are finding from experience that it is the better qualities of forest that give us the most successful gaps, and that the poorer the quality of the forest the less successful are the gaps, which may even completely disappear in many places. Other factors such as *Lantana* in open forest, or bamboos, may make an area unsuitable. I have just been over some of the original experimental gaps at Mount Stuart, in an area where thorny bamboo had seeded shortly after planting and of 22 gaps that were inspected, I found teak trees in 4. Out of those 4, one had 5 promising young trees in it ; two others had two promising trees each and another had one just showing above the *Lantana.* In good quality areas however we do get most surprisingly good results. In a couple of years we sometimes get the teak up to 8 feet and the results look very promising. With regard to the original gaps that were planted in 1918, from which the inspiration for the later gap planting was taken, there we had a fair amount of success. The quality of the forest was good, and there was a certain amount of bamboo in it. The District Forest Officer thinks that he can now recognise about 75 per cent. of the gaps, and although many of them have been damaged by *Lantana* most of them contain at least one promising tree. On financial grounds the gap system can be shown to be economically sound on its own merits ; that is to say, in suitable areas a gap costs about two rupees to establish and on an average we expect to get at least one and probably one and half trees per gap. A good tree in a good quality forest may give a return, of fifty or a hundred rupees. But we are finding that it is often very difficult to find a sufficient number of gaps suitable to replace the number of trees removed. We are improving the forests only locally, and according to Mr. Trevor's argument it would appear that we would hardly be justified in doing the present selection fellings in areas that are not suitable for gap regeneration.

The question of small plantations as compared with gaps has been raised. As Mr. Trevor said, economically and financially the former are a better proposition for the quantity of teak that you can produce at a given cost. Mr. Trevor urged that the rest of the forest should not be devastated. After our selection fellings in which we remove our good kinds of trees, the inferior species come in from seed and the forest does degenerate economically and in time you would have a forest which has practically no valuable trees left in it. But there still would be a forest and an area of plantation in the most suitable portion of that forest will produce a larger quantity of teak for the same expenditure than would be obtained from an equivalent area of gap regeneration. You are not destroying the forest ; you are merely transferring the productive capacity to a small area instead of spreading it over the whole forest.

Regarding the psychological aspect, the forest guards do take a very great interest in their gap regeneration work. I think it could also be argued that a forest guard would take a similar interest in small plantations and he might even do *taungya* in small plantations which would be an additional incentive.

It is true that we have practically no natural regeneration of teak in our better quality areas. Year after year selection-fellings have been going on and the forests had gradually deteriorated until this gap regeneration was started, and it is hoped that by this method we shall gradually improve the productivity of our forests under selection-fellings.

Mr. Villar : I have really nothing to report on this matter, but when the Inspector-General goes over to Burma, as he is going to do very shortly, he will also find there as he found in Madras, that natural regeneration of teak is conspicuous by its absence in the selection forests, specially in the better areas. What Mr. Laurie said about Madras also appears to be applicable to conditions in Burma. Speaking on very general lines we have divided our forests up into what we call accessible forests and forests which can be made accessible. The former are known as the local trade working circle and it is there that we have our teak plantations. I am speaking now more particularly of the Pegu Yomas that is to say divisions like Tharrawaddy and Toungoo. One of the great points in making these plantations is first of all to extract from the plantable area all the marketable timber. The scheme starts of first of all with the stock mapping of the area and then the girdling of teak, followed in three years' time by the extraction of teak and that is again followed by the extraction of other species, and in due course by a burn and the usual plantation work. Behind this local trade working circle we have our main selection forests and it is certainly a fact in my opinion that in these areas more work must be done in the way of regeneration. But the difficulty is the enormous areas that are covered and the degree of control required. We can omit perhaps altogether any considerations of revenue from other species, but if other valuable species cannot be extracted we might just as well fell them or burn them. The reason why plantations have gone forward so much in Burma has been due to the fact that we preferred this method of regenerating and improving our forests rather than trying natural regeneration in the selection forests in the interior. Conditions there seem to be rather similar to what Madras has found.

Mr. Pillai : Our conditions are more or less the same as in Madras and we also are trying to do something in the nature of what Mr. Laurie has described. As regards teak in all the places where we have tried these experiments, the result has been successful but that is probably due to the special suitability of the locality.

Mr. Ramiengar : We started this gap regeneration as far back I think as 1906. The principle adopted was that trees should be felled of groups of two or three. All the bamboos were felled, the slash piled and the whole thing was burnt before the teak was planted. The result is generally satisfactory. I had an opportunity a couple of months ago to see the work that I had done as district officer in 1914 and I was satisfied with the result. I agree that it is absolutely necessary that where fellings take place in the absence of natural regeneration some artificial regeneration must be done. Considering the amount of revenue obtained from the selection forests I think it is necessary even at a certain expense to replace the stock which we have removed. I consider that the expense involved is not so high as to prevent our doing this.

Mr. Smythies : Actually we have not got any gap planting in the United Provinces. Our main species under the selection system is *sal,* and *sal* is an extremely difficult species to grow in any way without concentrated working.

Mr. Sunder Singh : This term ' gap regeneration ' is rather new to me, but in the selection forests of the hills I am definitely of opinion that planting can be very easily done so far as the deodar is concerned. Indeed this is prescribed in working plans.

Mr. Mobbs : May I ask what control you have over these gaps. Do you keep a record of the number of gaps planted, do you keep maps or what do you do because otherwise they will be completely lost sight of ?

Mr. Trevor : All the areas in the Punjab selection working plans in the hills that are prescribed to be regenerated or specially planted up are coloured pink on the maps by the working plan officer ; this does not apply to small gaps which are expected to regenerate naturally but if the working plan officer finds a blank area in a selection compartment or an area which is to be given special attention, that area is marked pink on the map.

Mr. Laurie : Every year all the gaps are actually marked on a large scale map and the guard and the ranger have copies. It is quite easy for any district officer to trace any gap at any time. In four or five years it may be slightly difficult to find some of the gaps but I did not find much difficulty myself. It is a little trouble making the maps but it has to be done.

Mr. Trevor : I do not think it matters very much whether you have a small gap or whether you have a slightly larger gap. What we should be concerned with is that adequate steps are taken in the selection forests to see that normal regeneration is put back on the ground. I think that is the fundamental object of all this work and that is really what we are concerned with. Some may prefer a gap which produces one tree and some may prefer a small plantation but I do not think it really matters in the least provided these forests are not devastated and steps are taken to see that in future they produce what they have produced in the past.

(The debate was then closed.)

ITEM 11 (*a*), (*b*), (*d*).

Statistical Research.

(*Revision of Statistical Code.*)

Suggestions for minor corrections of the *Statistical Code* were received from most provinces. They were examined *seriatim* by the Central Silviculturist and compiled in the form of draft addenda and corrigenda. This draft was scrutinised by a Committee consisting of Messrs. H. G. CHAMPION (Chairman), M. D. CHATURVEDI (United Provinces), H. C. WATTS (Central Provinces), HARNAM SINGH (Kashmir), M. A. KAKAZAI (Statistical Assistant) and S. S. NEGI (United Provinces), and accepted with a few small changes, the chief of which was that the numerical check on the number of trees removed in thinning should be simplified if possible. The only important change was the substitution of the diameter basis for age basis in stump analysis work, the choice of the previous conference between the two alternatives being now realised to be wrong for the greater part of the stump analysis work in India. Burma had particularly found the need of this change. The Silviculturist, Forest Research Institute, also made a proposal for facilitating computation work for sample plots without loss of accuracy by using sums of circles tables correct to two decimal places instead of the four place tables at present used. See note on p. 198.

Mr. CHAMPION presented the report of the committee. The following resolution was proposed by Mr. CHATURVEDI and was seconded by Mr. NEGI and passed by the conference without further discussion.

RESOLUTION ON ITEM 11 (*a*), (*b*),

RESOLVED that—

This Conference accepts the proposals of the Central Silviculturist for additions and corrections to the 1931 Statistical Code and recommends that if possible a new edition of the Code be issued. (For proposals, see pp. 178-197). *If this cannot be done, then only important short correction slips should be issued, and other matters should be dealt with by issuing a separate circular to those concerned. This Conference further recommends that for stump analysis work the method used for irregular crops should be adopted as standard for all crops.*

* * * * * * *

Report of Committee.

The Committee considered 57 amendments to the Statistical Code drafted by the Central Silviculturist on suggestions received from various sources. It was decided that details of computation procedure should be left to the Central Silviculturist and the proposals dealing with field work were accepted or amended. Special reference was made to stump analysis, thinning of sample plots, heartwood data and the use of standing sample trees.

A new edition of the Statistical Code should be published incorporating the alterations proposed by the Central Silviculturist as amended by the Committee (copy below). The issue of correction slips would not meet requirements. Stump analysis work in irregular crops should be done on a diameter basis instead of on an age basis for irregular crops.

The numerical check of the trees to be removed in thinning should be applied as a routine step in sample plot work.

Heartwood data should also be collected as a routine measure on trees measured for research purposes.

More extended use should be made of measurements of standing sample trees.

Report of the Siviculturist, Forest Research Institute, on action taken on passed by the 1929 Conference.

The resolution called for the publication of a new *Statistical Code* and this was completed by the Central Silviculturist and his staff in 1931, as Vol. II of the *Silvicultural Research Manual.* Action taken on the several sub-heads was as follows :—

11 (*a*). *Increment of trees without rings.*—It was recommended that the Central Silviculturist should further examine the methods proposed, testing them on the actual examples and putting them on record. The methods proved less satisfactory when testing on a bigger range of data than when applied to the small number of plots first utilised. Provisional Yield Tables for *Quercus incana* were published in 1934 as *Forest Bulletin* 83 but it is stressed that much further work on the subject is needed.

11 (*b*). *Stump and Stem Analysis.*—The resolution accepted the procedure subsequently incorporated in the Statistical Code, the chief point being the adoption of the measurement of radial increment by decades and the rejection of the ring count in unit lengths of radius. Though the resolution was proposed and carried by Burma officers, the procedure recommended has not found general acceptance in Burma and the matter again needs discussion. Bengal is collecting analyses especially for species being grown in plantations (35 species, 114 trees).

Draft Addenda and Corrigenda to the Statistical Code.

(Compiled from all proposals received).

P. 9. ***General Rule 6.***—Add a note.—

10′ has thus been standardised for *Holoptelea* in the United Provinces, 12′ for *Heritiera* in the Sunderbans, and 10′ for *Bruguiera* in the Andamans.

P. 9. *General Rule 8.*—(There has been an appreciable reaction in favour of the use of girths instead of diameters, the Central Provinces pressing for it for sample plot work and several workers for stump analysis work. For exceptionally large trees and for buttressed and fluted trees there is general agreement that girths should be used. I am against a change for sample plot work and all standard volume and form work except when a special case can be made out as for the examples just mentioned).

P. 10. *General Rule 18.*—The standardised stump allowances at present in use are appended. (Pages 184-186). They should be included in the *Code* if it is reprinted.

P. 10. *General Rule 23.*—Add to (*a*).—

In case of species with pronounced buttresses (notably *Bombax* and *Holoptelea girth should be measured* at 4½′ ; girth and diameter should also be measured at the standardised height for the cross mark (see Rule 6 above).

P. 11. ***Add to General Rule 23 (d).***—

For buttressed trees, a diameter measurement should be taken at the lowest acceptable point clear of the buttresses and at the nearest multiple of 5 ft. from the ground level which is above it and not less than 5 ft. The taper between these two points should be considered to continue evenly downwards to ground level, and the upper part of the tree measured in 10 ft. lengths as usual.

General Rule 23 (f) (3).—*Add*—This measurement is not required for branch smallwood of teak, *sal, chir* pine, deodar and blue pine, for which sufficient data are already available. Other species will also be excluded as data accumulate. [*Cf.* Field Rule 54, p. 121].

P. 11. ***General Rule 23.***—*Add* new General Rule 23 (f′).—

(f′). Sapwood thickness should be measured for all species in which differentiation of heartwood is or is likely to be important. For this purpose, it should be measured at both ends of one callipered diameter at the middle of the first (at 5 ft.) and last timber sections and at form quotient point [See (*g*) below]. This may be done by cutting a notch to the heartwood or with the use of an increment borer. Sapwood data are most urgently needed for *Shorea robusta, Cedrus deodara, Dalbergia sissoo, Tectona grandis, Acacia catechu* and *Dalbergia latifolia.*

P. 12. *To General Rule 24 (d) (2)*, add.—

In case of species with pronounced buttresses, the lowest log should be taken so that its midpoint is free from buttress effect.

P. 12. *General Rule 24.*—Add new General rule 24 (*h*).

Sapwood thickness should be measured for all species in which differentiation of heartwood is or is likely to be important. For this purpose it should be measured at both ends of one callipered diameter, at both ends of the commercial bole, and at the middle.

P. 14. *Form Quotient Volume Tables.*

At the bottom of the page. 4th. line from the bottom, insert the word " where " before " d = diameter " and close the bracket after the word " Constants " in the next line.

In the 2nd. line from the bottom, for y = percentage, read x = percentage, and in the bottom line for x = Form Quotient, read y =

P. 20. *Sample Plot Form No. 10.*—It is proposed that this form should be combined with Sample Plot Form 4 as in the appended draft (B). This is mainly used by the F. R. I. and combination is advisable if it reduces copying work.

P. 46. *Tree Increment Demarcation Rule 13.*—For " *should* " *read* " *may if convenient* ".

P. 46. *Tree Increment Plot Record Rule 21.*—The United Provinces would prefer to include these plots in the standard sample plot sequence to avoid confusing the territorial staff. Others including the Central Silviculturist consider that the standard sample plot for which everything in field and office is on a fixed routine, should continue to be kept separate. (This seemed to be the opinion of the majority of the committee. Linear Plots could be included in the Tree Increment Plot series).

P. 50. *Stump Analysis Field Rule 6.*—Add " Buttressed stumps are unavoidable for teak and some other species. The analysis may then be done higher on the stem, even at the top of a short first log which will be considered as though it were the true stump under Sections (B)—(D) below, with small modifications of procedure ".

P. 52. *Stump Analysis Field Rule 17.*—[Opinion in Burma has changed in favour of the unitary count as described in the 1929 Proceedings and it is proposed that this be accepted as the standard for all stump analysis work. Sections (E) to (H), the forms, and the computations would require rewriting, a draft being appended.]

P. 54. *Stump Analysis Field Rule (H).*—Add :—

6. *Sapwood thickness.*—Under General Rule 24 (*h*) if commercial volume is being recorded, but under 23 (*f*) if only standard volume is taken.

P. 74. *Stem Analysis Field Rule (H).*—Add :—

(*g*) Diameters over and under bark at the mid point of the commercial bole (Bark percentage in commercial bole).

(*h*) *Sapwood thickness.*—Under General Rule 24 if commercial volume is being recorded, but under 23 (*f*) if only standard volume is taken.

P. 74. *Stem Analysis Field Rule 23 (b).*—

full stops after the word ' sides ' and after the word ' length ' and put a semicolon outside the brackets and add " and average width of crown rejecting single abnormal branches and twigs ".

Item 11 (a), (b), (d).]

P. 76. *Stem analysis computation step 4.*—In striking the averages, the number by which the total is divided should be the number of trees which reach the decade concerned, irrespective of whether they reach the height of the section.

(*Note.*--This has not been done in the example worked out on pages 88-90, which is to this extent incorrect and needs revision.)

P. 82. *Stem Analysis, Tree No. 4.*

The radial measurements of section 11 have been omitted for decade 90 and this error is carried through the computations.

P. 83. *Stem Analysis, Tree No. 5.*

There should be no radial measurement for Section 13 at decade 90, and this error is carried through the computations.

P. 86. *Stem Analysis Form 3.*—For HEIGHT in heading, read AGE.

P. 98. *Increment Borings Field Rule 9.*

When sapwood can be distinguished on the boring, 2 additional columns should be added to the form and headed. *Rings of sapwood* and *thickness of sapwood.*

P. 100. *Increment Borings Computation Section* (*b*).

Add at the end as a (small type) note. The method described leaves the adjustment for increment in bark thickness till the last step and this is not actually illustrated in the curves and figures reproduced. The advantage of this order of procedure is that the final figures can be very easily adjusted if any alteration of the bark percentage data becomes advisable, as is possible in view of the fact that they will usually be collected independently of the actual increment borings. The adjustment is made on Curve B by reading the twice-bark-thickness value against diameters 8″, 12″. 16″, etc., on the Twice-bark-thickness D. B. H. curve, deducting from each the value for the initial diameter of 7.1″, and plotting the remainders above the corresponding points on curve B : the curve through these new points is the final curve. This method involves the assumption that the increment in bark thickness in the 5 year intervals is so small that ignoring it only makes a negligible difference to the increments read off curve A.

It is however equally simple to work throughout in diameters under bark by applying the bark thickness data to the d. b. h. measurements taken over bark. Curve A would then refer entirely to under-bark measurements and Curve B would be shifted up by twice the bark thickness for representative trees.

P. 117. *Sample Plot Field Rule 24* (*a*).—For *Sample Plot* read *Permanent Sample Plot.*

P. 117. Insert new Rule 24 (*b*).

Temporary plots should have a separate sequence of numbers for each species in each division.

P. 117. *Sample Plot Field Rule 25.*—At the end of the first para. add.—

Before felling the trees selected for removal in thinning. the mean diameter (by basal area) of the trees that will be left standing should be calculated. and their number per acre compared with the *n/d* curve for the species and fractional quality class concerned as given in the yield tables ; the latter are considered to refer to C—grade ordinary thinning. Trees about which there is doubt should be felled or retained according to which step will bring the plot nearer to the yield table figures in this respect.

Committee accepted the principle involved but recommended that the Central Silviculturist should check whether this procedure could not be simplified by using arithmetical mean diameter instead of diameter of tree of mean basal area).

Ex. 36a. *Shorea robusta,* Quality Class 0.9 II (from $a = 88$, $h = 95$ ft.), area 0.17 acre ; after marking the thinning $d = 17.2''$ and $n = 88$ for the remaining crop. From the yield table when $d = 17.2''$, $n = 77$, so that the stocking is 114 per cent., too high. The inclusion of three doubtful stems in the thinning altered the figures to 18.3″, and to 71 compared with 68 stems, or 104 per cent. which was accepted.

P. 120. *Sample Plot Field Rule 45.*—Omit the words " of sight " in the 5th. line.

P. 120. *Sample Plot Field Rule 47.*—After the 1st sentence add :—

" Trees so measured should be remeasured at future measurements as long as they are acceptable as sample trees ". In place of the note on this rule, read " Measurement of standing sample trees has been described in Forest Bulletin No. 82 of 1933, which may be referred to for details. Smallwood measurements of standing trees can not be obtained as a rule, but when the shape of the crown is such that diameters can be measured for one or more stem smallwood sections these measurements should also be taken."

P. 121. *Sample Plot Field Rule 57.*—Add :—

" Crown width of standing trees may be measured on any of the methods described in *For. Bull.* No. 82 (1933), pages 13-15, the reflecting crown meter being recommended for the purpose. The average of two diameters rejecting single abnormal branches or twigs should be recorded ".

(The committee recommended that the details should be included in the *Code* if it is reissued.)

P. 121. *Sample Plot Field Rule 58.*—This rule may be deleted or the following rule substituted in its place.

" It is useful to record the diameter over and under bark at half total height to permit of the calculation of bark percentage.

This measurement is not required for *sal*, teak, deodar, *chir* and blue pine, for which sufficient data already exist.

P. 121. *Sample Plot Field Rule 60.*

In 1st line substitute 48 in place of 49.

P. 124. *Sample Plot Field Rule 75.*—Add :—

" Standing heights of the trees measured under Rule 61 should be remeasured if still acceptable as sample trees, with those of additional trees if necessary.

Trees that are found missing should be taken as thinned and their last recorded diameters accepted. If a tree that was missed at the last measurement is found at a subsequent remeasurement, its diameters should be taken and recorded. The thinning should be carried out as prescribed under Rule 25, p. 117."

P. 125. *Sample Plot Field Rule 79.*—Add the words " with their slopes " after the word " plot ".

P. 125. *Sample Plot Field Rule 80.*—For (*ii*) Substitute :—

" Height of the standing trees previously selected for measurement and any additional trees necessary to cover the height and diameter range of the plot ".

Add as a note in small type.

The primary object of the interim remeasurement is to check that all is in order. In addition, it ensures that the maximum amount of useful data is available at any time for compilation of yield tables or other statistical information which is often called for.

P. 126. The second sentence of *Sample Plot Computation Rule* (*2*) (*a*) should read as " For mid-diameters of volume sections, 0.05 is taken alternately as 0.1 and nil ".

Item 11 (a), (b), (d).]

P. 127. *Sample Plot Computation Rule 2 (g).*—This will be omitted if bark percentage is no longer computed.

P. 127. *Sample Plot Computation Rule 4,* 3rd line for p. read p. 168.

P. 128. *Sample Plot Computation Rule 9.*—Add :—

For standing sample trees in which no direct measurements of smallwood can normally be obtained the required diameters for the stem smallwood sections are computed by using Behre's stem form equation $y = x/(a + bx)$ where x is the percentage relationship between the distance of any point from the top of the tree, and the total height above breast height ; y is the ratio of the diameter at that point to d. b. h. ; a and b are constants. A graphical solution is obtained by plotting the x/y curve for the timber measurements. Extrapolation of the curve should pass through the point $x = 100$, $y = 1$ when unless there is butt swelling but usually it is necessary to correct for this by recalculating y values for a reduced d. b. h. obtained by multiplying actual d. b. h. by the value of y when $x = 100$ on the curve, and redrawing the latter through the new points. The values of a and b can now be calculated by substituting the values of y from the curve when $x = 50$ and 100. The length of stem smallwood is next calculated by solving for x when $y = 2''$ d. *b. h.*, and converting the percentage obtained into actual length. This length is divided into sections in accordance with General Rule 23 (*f*) (3) and the heights obtained for which mid-diameters are needed ; x is then known for each and y is derived from the equation and converted into the diameters required.

P. 130. *Sample Plot Computation Rules (K).*—4th line from top for p. 18, read p. 182.

P. 130. *Sample Plot Computation Rule 22 (b).*—In the 3rd line of para. 2, read " Cols. 16, 17, 26 and 27 " for " Cols. 16 and 17 ".

P. 130. *Sample Plot Computation Rule 23.*—Add as a note :—

' Mixed plots having less than 10 per cent. of accessory and auxiliary species are ordinarily considered acceptable for the compilation of yield and stand tables for pure crops.'

P. 130. *Foot note* : The form has been corrected, so this foot note should be deleted.

P. 132. *Sample Plot Computation Rule 26 (1), 3rd line.*—For Curve IV, read Curve VI.

Similarly under Rule 27 (*b*), last line.

P. 133. *Sample Plot Computation Rule 29, 7th line.*—For Curve IV, read Curve VI.

Similarly under Rule 32, 4th line.

P. 134. Add *Rule vii (a). Computation of interim measurements.*

Average diameter and basal area per acre will be computed. The height data will be plotted with a special symbol on the last height curves and any discrepancies discovered noted on Form 2 (*a*). Form 5 will be filled in for Col. 1-7 and Form 6 for Cols. 1-4 and 10-13.

P. 137. Ex. 36.

$$\text{For } s = \frac{\text{log. } 02107 - \text{log. } 01906}{\text{log. } 6.0 - \text{log. } 5.4}$$

$$\text{Substitute } s = \frac{\text{log. } 01906 - \text{log. } 02017}{\text{log. } 5.4 - \text{log. } 6.0}$$

P. 143. *Sample Plot Computations.*—Appendix III,

For " over 8″ read 8″ and over ", throughout.

Add before the example—" When the number of diameters below 2″ is 25 or more per acre, they should form a separate group ".

P. 158. *Sample Plot Form No. 4.*

Revision is advisable to avoid copying in unnecessary figures from Form 7 and to include other data now required. A combined Form replacing Forms 4 and 10 is preferable and a draft is appended (A). (The committee considered that bark thickness and bark per cent. could be omitted.)

P. 182. *Sample Plot Form 6.*—The alteration of the headings in columns 16 and 26 for Total (smallwood) to Branch (small-wood) have already been made.

P. 186. *Sample Plot Form 7.*—Revision is necessary to include headings for additional data to be collected. Proposed revised form is appended (B).

P. 214. *Sample Plot Form 11.*

Add at the foot of the Form after " Notes ".

" Owing to a mistake, the standard grouping (p. 144) has not been followed ; the groups should have been 25, 31, 68 per acre or 4, 5, 11 for the plot ".

P. 216. *Sample Plot Form 11.*

Add at the foot of the Form after " *Notes* ".

" Owing to a mistake the standard grouping (p. 144) has not been followed : the groups should have been 25, 31, 68 per acre or 4, 5, 11 for the plot ".

P. 219. Add :—

Note.—The above rules for different grades of thinnings are not applicable to dense young crops both natural and artificial in which the differentiation into canopy classes has not become marked. The only check that thinning intensity in different plots is the same is by comparing with the yield table number of stems for the same crop diameter where a yield table is available. See p. 117, S. P. Field Rule 25.

P. 241. *Stand Tables, step* (*a*).

For *diameters* read *stems.*

P. 241. VII (f).—Add :—

Crown space data can be used for predicting the probable future number of stems per acre corresponding to any required mean diameter of pure crops in combination with crown width measurements of dominant trees of the same diameter range in natural forests.

For this purpose the d. b. h. and crown diameters of all trees on known areas of plantations of all available ages should be measured, care being taken that the area is large enough to eliminate marginal effects and that the stocking is neither over dense nor poor. The crown diameters should be squared and totalled for each area separately and the total divided by the area giving the ratio Crown space|Plot area and the corresponding d. b. h. Crown space|Plot area should then be plotted against d. b. h. and a curve drawn and extrapolated over the required diameter range.

Crown and d. b. h. measurements of dominant trees of the crown form to be aimed at and covering the diameter range needed should be taken in natural forests, and the values plotted to give a curve from which average crown width for any diameter can be read.

By dividing the square of the crown width by the corresponding ratio, crown space is obtained in square feet and from this, stocking in number of trees per acre is derived by dividing it into 43560.

Item 11 (a), (b), (d).]

Correction of age based on ring countings on stumps.

Natural Regeneration.						Artificial Regeneration.					
Stump height. Inches.	Quality.				Species.	Stump height. Inches.	Quality.				Remarks.
	Average.	I.	II.	III.			Average.	I.	II.	III.	
					ABIES PINDROW.						
2	1	..	..	..		..	..	..	..	..	
3	2	..	..	..		..	..	..	..	..	
4—5	3	..	..	..		..	..	..	..	..	
6—8	4	..	..	..		..	..	..	..	..	
9—11	5	..	..	..		..	..	..	..	..	
12—14	6	..	..	..		..	..	..	..	..	
15—18	7	..	..	..		..	..	..	..	..	
19—22	8	..	..	..		..	..	..	..	..	
23—26	9	..	..	..		..	..	..	..	..	
27 and over	10	..	..	..		..	..	..	..	..	
					ACACIA CATECHU.						
Up to 6	1	..	..	..		..	..	..	..	..	
7—12	2	..	..	..		..	..	..	..	..	
13—24	3	..	..	..		..	..	..	..	..	
Above 24	4	..	..	..		..	..	..	..	..	
					ANOGEISSUS PENDULA.						
Up to 10	1	..	..	..		..	..	..	..	..	
11—20	2	..	..	..		..	..	..	..	..	
					CEDRUS DEODARA.	(a)	*Sowings.*				
3	..	1	2	3		3	..	1	1	2	
4	..	2	3	4		4	..	1	2	3	
5	..	2	4	5		5	..	1	3	4	
6	..	3	4	5		6	..	2	3	4	
7	..	3	5	6		7	..	2	4	5	
8	..	4	6	7		8	..	3	5	6	
9	..	4	6	7		9	..	3	5	6	
10	..	5	7	8		10	..	4	6	7	
11	..	5	8	9		11	..	4	7	8	
12	..	6	8	10		12	..	5	7	9	
13	..	6	9	11		13	..	5	8	10	
14	..	7	10	12		14	..	6	9	11	
15	..	7	10	12		15	..	6	9	11	
16	..	7	10	13		16	..	6	9	12	
17	..	7	11	13		17	..	6	10	12	
18	..	8	11	14		18	..	7	10	13	
19	..	..	11	..		(b)	*Transplants.*				
20	..	..	11	..		Up to 2	1	1	1	..	
21	..	..	11	..		3—6	2	2	2	..	

Correction of age based on ring countings on stumps—contd.

Natural Regeneration.						Artificial Regeneration.					
Stump height. Inches.	Quality.				Species.	Stump height. Inches.	Quality.				Remarks.
	Average.	I.	II.	III.			Average.	I.	II.	III.	
					CEDRUS DEODARA.						
22	..	..	12	..		7—9	3	3	3	..	
23	..	..	12	..		10—12	3	4	4	..	
24	..	..	12	..		13—15	4	4	5	..	
25	..	..	12	..		16—18	4	5	6	..	
					EUGENIA JAMBOLANA.						
4	1	..	..	..		7	1	..	..	..	
5—8	2	..	..	..		8—14	2	..	..	..	
9—14	3	..	..	..		15—24	3	..	..	..	
15—20	4	..	..	..		..	..	..	..	..	
21—28	5	..	..	..		..	..	..	..	..	
					HOLOPTELEA INTEGRIFOLIA.						
Up to 5	1	..	..	..		..	..	..	..	..	
5—24	2	..	..	..		..	..	..	..	..	
Over 24	3	..	..	..		..	..	..	..	..	
					PICEA MORINDA.						
2	1	..	..	..		..	..	..	..	..	
3	2	..	..	..		..	..	..	..	..	
4	3	..	..	..		..	..	..	..	..	
5	4	..	..	..		..	..	..	..	..	
6	5	..	..	..		..	..	..	..	..	
7—8	6	..	..	..		..	..	..	..	..	
9—11	7	..	..	..		..	..	..	..	..	
12—15	8	..	..	..		..	..	..	..	..	
16—20	9	..	..	..		..	..	..	..	..	
21 and over	10	..	..	..		..	..	..	..	..	
					PINUS EXCELSA.		*Sowings.*				
Up to 3	..	1	2	2		Up to 4	..	1	2	2	
3—4	..	2	3	3		4—6	..	2	3	4	
5—6	..	3	4	5		7—9	..	3	4	5	
7—9	..	4	5	6		10—12	..	3	4	5	
10—12	..	4	5	6		13—15	..	4	5	6	
13—15	..	5	6	7		16—18	..	4	5	6	
16—18	..	5	6	7		19—21	..	4	5	7	
19—21	..	5	6	8		22—24	..	5	6	7	
22—24	..	6	7	8		..	..	..	..	..	
					PINUS LONGIFOLIA.						
1—2	1	..	..	..		..	..	..	..	..	
3—6	2	..	..	..		..	..	..	..	..	
7—12	3	..	..	..		..	..	..	..	..	
13—20	4	..	..	..		..	..	..	..	..	
21—34	5	..	..	..		..	..	..	..	..	

Item 11 (a), (b), (d).]

Correction of age based on ring countings on stumps—concld.

Natural Regeneration.						Artificial Regeneration.					
Stump height. Inches.	Quality.				Species.	Stump height. Inches.	Quality.				Remarks.
	Average.	I.	II.	III.			Average.	I.	II.	III.	
					QUERCUS DILATATA.						
2—4	1	..	..	..		..	..	..	..	..	
5—8	2	..	..	..		..	..	..	..	..	
9—13	3	..	..	..		..	..	..	..	..	
14—18	4	..	..	..		..	..	..	..	..	
19—23	5	..	..	..		..	..	..	..	..	
24—30	6	..	..	..		..	..	..	..	..	
					QUERCUS INCANA.						
11	5	..	..	..		11	4	..	..	..	
12—16	6	..	..	..		12—16	5	..	..	..	
17—21	7	..	..	..		17—21	6	..	..	..	
22—26	8	..	..	..		22—26	7	..	..	..	
27—32	9	..	..	..		27—32	8	..	..	..	
33—37	10	..	..	..		33—37	9	..	..	..	
38—43	11	..	..	..		38—43	10	..	..	..	
					QUERCUS SEMECARPIFOLIA.						
2—3	1	..	..	..		..	..	..	..	..	
4—5	2	..	..	..		..	..	..	..	..	
6—7	3	..	..	..		..	..	..	..	..	
8—10	4	..	..	..		..	..	..	..	..	
11—13	5	..	..	..		..	..	..	..	..	
14—16	6	..	..	..		..	..	..	..	..	
17—19	7	..	..	..		..	..	..	..	..	
20—23	8	..	..	..		..	..	..	..	..	
24—27	9	..	..	..		..	..	..	..	..	
					SHOREA ROBUSTA.						
1—6	1	..	..	..		..	..	..	..	..	
7—12	2	..	..	..		..	..	..	..	..	
13 and above	3	..	..	..		..	..	..	..	..	
					TERMINALIA TOMENTOSA.						
Up to 5	1	..	..	..		8	1	..	..	..	
6—8	2	..	..	..		9—15	2	..	..	..	
9—11	3	..	..	..		16—24.	3	..	..	..	
12—14	4	..	..	..		..	..	..	..	..	
15—18	5	..	..	..		..	..	..	..	..	
19—22	6	..	..	..		..	..	..	..	..	
23—27	7	..	..	..		..	..	..	..	..	

BOMBAX MALABARICUM, MORUS ALBA, DALBERGIA SISSOO AND TECTONA GRANDIS.

No stump allowance is to be added as the rate of growth is too rapid to need any allowance for stump.

Item 11 (a), (b), (d).]

DRAFT FORM A.

Summary of sample tree measurements.

Species..........

Sample Plot Form (4 & 10).

Height class.................

Diameter class..................

Division.	Sample plot No.	Sample tree No.	Age.	Diameter at 4½ ft.	Total height.	Length of shoot of last......years.	Form Factors.				Solid volume.				Bark thickness at 4½ ft.	Bark % of total volume.	Length of stem timber.	Crown length.	Crown width.	$\frac{\text{Crown length.}}{\text{Total height.}}$	Form quotient.		Percentage of sapwood in stem timber.
							Timber.		Smallwood.		Timber.		Smallwood.								Over bark.	Under bark.	
							Stem.	Branch.	Stem.	Branch.	Stem.	Branch.	Stem.	Branch.									
			Years.	Ins. & dec.	Ft.	Ft. and dec.	To three places of decimals.				Cubic feet to two places of decimals.				Ins. & dec.		Ft.	Ft.	Ft.	To three places of decimals.			

[Item 11 (a), (b), (d).
Sample Plot Form No. 7.

DRAFT FORM B.

F. R. I. 28. Measurement of Sample trees, Division. Sample Plot No. , Date , Initials.

Sample tree number.	Species.	Age.	Total height.	Length of shoot of last—— years.	Diameters at 4½'.			Corresponding basal areas at 4½ ft.	Diameters in inches and decimals.					Remarks.
										At right angles.		Average.		
		Years.	Feet.	Ft. and decimals.		At right angles.	Average.	Sq. ft. and decimals.		Over bark.	Under bark.	Over bark.	Under bark.	
					O.B.				At half total height					
					U. B.				At half height above 4½ ft.					Volume of cylinder = Bark per cent. =
					Number of rings on stump .. .. Height of stump .. .. ins.				Height of first green branch. Ft.	Height of green branches all round. Ft.	Average. crown height. Ft.	Length of crown. Ft.	Width of crown. Ft.	Bark thickness at 4'—6" = Form quotient. O.C. = U.C. = Sapwood per cent. in stem timber. =

	Volume Measurements.													Form Factors.		
	Timber down to diameter over bark of 8 inches.						Smallwood down to diameter over bark of 2 inches.									
Thickness of sapwood.	Length.	Mild-diameters without bark.			Sectional area.	Volume.	Length.	Mid-diameters over bark.			Sectional area.	Volume.	Timber.	Smallwood.	Timber and Smallwood.
		At right angles.		Average.				At right angles.		Average.					
Ins. & dec.	Feet.	Inches and decimals.			Sq. ft. and decimals.	Cub. ft. and decimals.	Feet.	Inches and decimals.			Sq. ft. and decimals.	Cub. ft. and decimals.	To three places of decimals.		
1st section.]															
Last section.															

[Item 11 (a), (b), (d).

Revision of Stump Analysis procedure to the method based on counting rings in unit length of radius.

[*Cf. Proc. Silv. Conf.* 1929, pages 181 *et. seq.*, and *Stat. Code*, C. VII, p. 49, *et seq.*, particularly the note to Field Rule (17), p. 52].

Note.—For growth statistics of unevenaged forest—and stump anlysis work is mainly concerned with this type—a diameter basis is preferable to an age basis. Moreover stump analysis data are most usually required for teak and other typically buttressed species and girth is preferable to diameter on practical grounds. The alternative method (rejected by the 1929 Conference) is accordingly again put forward for use for unevenaged forest, with or without a recommendation that for the sake of uniformity it should be the standard method for all stump analysis.

Statistical Code, C. VII (*iii*) Field work (p. 50).

(*A*) *Selection of trees.*—Unchanged (p. 50).

(*B*) *Stump height.*—Unchanged (p. 51).

(*C*) *Age to stump height.*—Unchanged (p. 51).

(*D*) *Taper measurement.*—Unchanged (p. 51) except to substitute *girth* for *diameter.*

(*E*) *Ring counts and radial measurements.*—(p. 52).

(14) The girth under bark should be measured and the corresponding radius calculated.

(15)*c.* Delete the sentence from and including dash, *viz.*—unless balanced ....used.

(16) Unchanged.

(17) On each radius so marked a pin should be inserted at each unit of length, normally ½″ or 1″, leaving the incomplete unit on the outer edge of the stump.

In case of radii appreciably differing from the average radius the unit should be adjusted by multiplying by the ratio Radius under examination/Average radius ; the corrected unit length should be taken and the radius marked off with a divider beginning from the pith.

(18) The number of rings should be counted from the pith outwards to the ring nearest to each pin up to the edge of the stump. Errors will be introduced if the stump surface is not plane and horizontal.

(*F*) *Field Work for hollow stumps.*—Unchanged.

P. 53. (*G*) *Record of Field data.*

Ex. 31—a complete but simplified example is given below.

(*a*) *Stump Analysis Form I.*

In this form number of rings correspondending to radii of 1″, 2″, 3″, etc., and stump height and stump diameter under bark are recorded. Measurements corresponding to the outermost fraction of a unit are not made or recorded. A separate form should be used for each locality quality.

Species
Quality.

Division.
Block & Compt.

Stump Analysis Form No. 1.

Serial No.	Stump Ht.	Girth at stump height Inches.	Calculated average radius at stump height under bark.	Number of rings per radius of								Total radial length.	Total no. of rings.
				1″	2″	3″	4″	5″	6″	7″	8″		

Item 11 (a), (b), (d).]

(*b*) and (*c*) Unchanged.

(*H*). *Additional measurements recommended.*—Unchanged.

(*iv*) *Computations.*

(*a*). *Stump diameter—Stump age curve.*

(1) For each tree the ages corresponding to the average radii are added and averaged. This average age corresponds to diameter equal to double the average radius, *viz.* 2″, 4″, 6″, etc.

(2) The average ages so obtained should be brought on to a new form and averaged.

(3) These average ages are then plotted against diameters and a smooth curve drawn.

(*B*) *Correction from stump age to total age.*

(4) and (5) Unchanged.

(6) The age scale of the curve is shifted downwards by a number of units equal to the number of years so determined for age to average stump height in the example.

(*C*) *Conversion of stump diameters under bark to d. b. h. over bark.*

(7) to (11) Unchanged.

P. 55. (*D*) *Computation for hollow stumps.*

(12) The data for the small trees are marked up exactly as prescribed above resulting in a curve for stump age over stump diameter under bark for a range of 2″ diameter to diameter of *C.*″

(13) Curve I is constructed in the same way for the measurements on the hollow trees but will represent the relation between stump age (minus age to *C* inches) and stump diameter (minus *C* inches).

(*E*) When the sum........proportionately. Remains unchanged.

(16) This may be done (1) before the average counts for the individual trees are totalled and averaged or (2) afterwards. In the first case the average counts for the tree are multiplied by a factor equal to the *Total of the 4 radii examined|Four times average radius.* The multiplication can be done—

(*a*) directly,

(*b*) by slide rule,

(*c*) graphically. A line indicating the ratio of *Average of radii measured|Average radius of tree* is drawn and scales of ages corresponding to average radius and to average of the radii measured are marked off using the same unit. Then the ages required are read off.

In the 2nd case, totals and averages for (*a*) four times the average radius (*b*) rings in each unit length and (*c*) total of 4 radii of all the trees are obtained.

Then the average number of rings in each unit is multiplied by $\frac{\text{Average of total of 4 radii}}{\text{Average of 4 times average radius}}$ and the correction is applied in one step. This procedure gives all the accuracy needed.

Stump Analysis Form No. 1.

Species. **Cedrus deodara.**

Quality. III.

Division. *Chakrata.*

Block and Compartment. *Mundali 2.*

Serial No.	Stump height.	Girth at stump height. Under bark.	Calculated average.	Sapwood measurements.		Number of rings for radius of																		Total radial length. Inches.	Total number of rings.	Remarks.
			Radius at stump height. Under bark in inches.	No. of rings.	Average thickness in inches.	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″	17″	18″			
1	1′—8″	12′—9·3″	24·05	..	..	10	15	19	24	30	35	41	47	53	60*	..	..	..	..	..	..	..	..	23·8	..	
	..	..	..	..	..	8	14	19	23	28	32	35	39	44	49	..	..	..	..	..	..	..	..	24·2	..	
	..	..	..	..	..	8	14	19	24	31	37	44	50	57	65	..	..	..	..	..	..	..	..	24·0	..	
	..	..	..	..	..	7	13	17	21	26	31	37	42	47	52	..	..	..	..	..	..	..	..	24·1	..	
				Total	..	33	56	74	92	115	135	157	178	201	226	..	..	..	..	..	..	..	..	96·1	..	
	..	..	..	Average		8	14	19	23	29	34	39	45	50	57	..	..	..	..	..	..	..	..	24·0	..	
2	0′—5″	8′—3·5″	15·6	..	..	25	60	84	94	102	109	115	122	130	136	143	151	158	164	170	178	186	..	17·65	191	
	..	..	..	..	..	29	73	93	105	116	127	140	153	162	174	190	..	..	..	..	..	..	..	11·15	..	
	..	..	..	..	..	26	37	60	79	91	98	105	111	118	125	132	140	147	155	165	175	..	..	16·90	..	
	..	..	..	..	..	25	36	59	75	88	97	104	110	117	126	137	146	153	162	173	186	..	..	16·45	..	
				Total	..	105	206	296	353	397	431	464	496	527	561	602	..	..	..	..	..	..	..	62·15	..	
				Average ..		26	52	74	88	99	108	116	124	132	140	151	..	..	..	..	..	..	..	15·54	..	
				Adjusted ..		26	52	74	88	99	108	116	124	131	139	..	..	..	..	..	..	..	..	..	..	

*NOTE.—As the data from the trees used for this example did not permit of compilation beyond 10″ radius, the further counts on longer radii are omitted except for trees Nos. 2 and 4 which are completed as illustrations of typical counts.

Item 11 (a), (b), (d).]

UNIT MEASUREMENTS.

Stump Analysis Form No. 1.

Species. Cedrus deodara.

Division. *Chakrata.*

Quality. III.

Block and Compartment. ***Mundali 2.***

Serial No.	Stump height.	Girth at stump height. Under bark.	Calculated average.	Sapwood measurements.		Number of rings for radius of																		Total radial length. Inches.	Total number of rings.	Remarks.
			Radius at stump height. Under bark in inches.	No. of rings.	Average thickness. Inches.	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"	17"	18"			
3	2′—0″	11′—2·9″	21·15	..	..	9	15	21	24	28	32	36	40	46	56	..	..	..	..	..	..	..	..	30·55	..	
						10	17	23	29	35	43	51	60	69	80	..	..	..	..	..	..	..	..	17·35	..	
						12	20	26	32	39	49	56	66	75	83	..	..	..	..	..	..	..	..	15·85	..	
						10	17	23	27	33	38	44	50	58	66	..	..	..	..	..	..	..	..	19·75	..	
				Total ..		41	69	93	112	135	162	187	216	248	285	..	..	..	..	..	..	..	..	83·50	..	
				Average ..		10	17	23	28	34	41	47	54	62	71	..	..	..	..	..	..	..	..	20·88	..	
				Adjusted ..		10	17	23	28	34	40	46	53	61	70	..	..	..	..	..	..	..	..	..	..	
4	0′—3″	6′—6·1″	12·25	..	..	11	19	28	41	57	74	96	116	136	151	163	180	..	..	..	..	..	..	12·35	190	
						12	22	35	54	71	84	105	116	125	140	162	176	..	..	..	..	..	..	12·55	..	
						12	23	42	57	83	105	124	138	150	165	179	..	..	..	..	..	..	..	11·80	..	
						11	20	31	46	60	81	97	112	124	141	155	175	..	..	..	..	..	..	12·80	..	
				Total ..		46	84	136	198	271	344	422	482	535	597	659	..	..	..	..	..	..	..	49·50	..	
				Average ..		12	21	34	50	68	86	106	121	134	149	165	..	..	..	..	..	..	..	12·38	..	
				Adjusted ..		12	21	34	51	69	87	107	122	135	151	..	..	..	..	..	..	..	..	..	..	

[Item 11 (a), (b), (d).

Stump Analysis Form No. 1.

Species. Cedrus deodara.

Quality. III.

Division. *Chakrata.*

Block and Compartment. *Mundali 2.*

Serial No.	Stump height.	Girth at stump height. Under bark.	Calculated average.	Sapwood measurements.		Number of rings for radius of																		Total radial length. Inches.	Total number of rings.	Remarks.
			Radius at stump height. Under bark in inches.	No. of rings.	Average thickness. Inches.	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″	17″	18″			
5	0′—3″	8′—8·3″	16·35	..	..	18	35	54	66	79	91	101	114	128	142	..	..	..	..	..	..	..	..	17·60	..	
						15	29	43	60	71	81	88	96	106	122	..	..	..	..	..	..	..	..	20·05	..	
						14	25	37	48	64	74	82	93	113	126	..	..	..	..	..	..	..	..	16·30	..	
						17	33	55	79	100	110	126	136	145	155	..	..	..	..	..	..	..	..	14·05	..	
				Total ..		64	122	189	253	314	356	397	439	492	545	..	..	..	..	..	..	..	..	68·00	..	
				Average ..		16	31	47	63	79	89	99	110	123	136	..	..	..	..	..	..	..	..	17·00	..	
				Adjusted		17	32	49	66	82	93	103	114	128	141	..	..	..	..	..	..	..	..	..	..	
6	0′—7″	8′—3·2″	15·55	..	..	10	22	29	37	46	58	69	80	92	104	..	..	..	..	..	..	..	..	15·20	..	
						10	18	29	40	52	65	76	88	100	109	..	..	..	..	..	..	..	..	16·30	..	
						11	22	24	50	64	77	85	93	101	109	..	..	..	..	..	..	..	..	14·05	..	
						9	20	28	37	46	54	63	74	87	95	..	..	..	..	..	..	..	..	16·05	..	
				Total ..		40	82	110	164	208	254	293	335	380	417	..	..	..	..	..	..	..	..	61·60	..	
				Average ..		10	21	28	41	52	64	73	84	95	104	..	..	..	..	..	..	..	..	15·40	..	
				Adjusted		10	21	28	41	51	63	72	83	94	103	..	..	..	..	..	..	..	..	..	..	

Item 11 (a), (b), (d).]

UNIT MEASUREMENTS.

Species. Cedrus deodara.

Quality. III.

Stump Analysis Form No. 1.

Division. *Chakrata.*

Block and Compartment. *Mundali 2.*

Serial No.	Stump height.	Girth at stump height. Under bark.	Calculated average.	Sapwood measurements.		Number of rings for radius of																		Total radial length. Inches.	Total number of rings.	Remarks.
			Radius at stump height. Under bork in inches.	No. of rings.	Average thickness. Inches.	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″	17″	18″			
7	2′—1″	10′—1·8″	19·10	..	..	13	21	27	32	39	45	52	58	64	71	..	..	..	..	..	..	..	..	26·25	..	
						13	21	27	36	45	53	58	67	77	86	..	..	..	..	..	..	..	..	19·10	..	
						13	22	29	41	51	62	72	84	96	108	..	..	..	..	..	..	..	..	15·05	..	
						14	24	31	41	49	58	71	82	96	100	..	..	..	..	..	..	..	..	13·70	..	
				Total ..		53	88	114	150	184	218	253	291	333	365	..	..	..	..	..	..	..	..	74·10	..	
				Average		13	22	29	38	46	55	63	73	83	91	..	..	..	..	..	..	..	..	..	..	
				Adjusted		13	21	28	37	45	53	61	71	81	88	..	..	..	..	..	..	..	..	18·53	..	
8	0′—5″	9′—7·4″	18·10	..	..	17	37	51	58	67	83	94	105	116	128	..	..	..	..	..	..	..	..	15·80	..	
						22	37	51	61	69	82	89	100	108	118	..	..	..	..	..	..	..	..	17·75	..	
						21	31	41	51	58	65	74	83	91	101	..	..	..	..	..	..	..	..	20·50	..	
						18	33	45	53	59	65	72	81	91	100	..	..	..	..	..	..	..	..	18·70	..	
				Total ..		78	138	188	223	253	295	329	369	406	447	..	..	..	..	..	..	..	..	72·75	..	
				Average		20	35	47	56	63	74	82	92	102	112	..	..	..	..	..	..	..	..	18·19	..	
				Adjusted		20	35	47	56	63	74	82	92	103	113	..	..	..	..	..	..	..	..	..	..	

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UNIT MEASUREMENTS.

[Item 11 (a), (b), (d).
Stump Analysis Form No. 1.

Species. Cedrus deodara.

Quality. III.

Division. *Chakrata.*

Block and Compartment. *Mundali 2.*

Serial No.	Stump height.	Girth at stump height. Under bark.	Calculated average.	Sapwood measurements.		Number of rings for radius of																		Total radial length. Inches	Total number of rings.	Remarks.
			Radius at stump height. Under bark in inches.	No. of rings.	Average thickness. Inches.	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"	17"	18"			
9	0'—11"	10'—1·5"	19·05	..	..	11	16	22	28	33	38	44	50	56	61	..	..	..	..	..	..	..	..	19·70	..	
						13	21	30	36	41	47	52	58	63	69	..	..	..	..	..	..	..	..	19·05	..	
						13	20	30	37	43	49	55	61	66	72	..	..	..	..	..	..	..	..	18·65	..	
						12	20	27	34	40	46	52	59	69	75	..	..	..	..	..	..	..	..	18·75	..	
				Total ..		49	77	109	135	157	180	203	228	254	277	..	..	..	..	..	..	..	..	76·15	..	
				Average		12	19	27	34	39	45	51	57	64	69	..	..	..	..	..	..	..	..	19·04	..	
				Adjusted		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
10	1'—9"	8'—9·9"	16·60	..	..	20	34	50	62	73	81	91	98	105	112	..	..	..	..	..	..	..	..	23·20	..	
						18	35	50	59	70	76	84	93	101	107	..	..	..	..	..	..	..	..	20·20	..	
						18	33	49	60	80	94	103	111	119	131	..	..	..	..	..	..	..	..	17·05	..	
						23	38	71	77	89	105	119	137	160	179	..	..	..	..	..	..	..	..	11·35	..	
				Total ..		79	140	220	258	312	356	397	439	485	529	..	..	..	..	..	..	..	..	71·80	..	
				Average		20	35	55	65	78	89	99	110	121	132	..	..	..	..	..	..	..	..	17·95	..	
				Adjusted		22	38	59	70	84	96	107	119	131	143	..	..	..	..	..	..	..	..	..	..	

Item 11 (a), (b), (d).]

Species. Cedrus deodara.

Quality. III.

UNIT MEASUREMENTS.

Stump Analysis Form No. 1.

Division. *Chakrata.*

Block and Compartment. ***Mundali 2.***

Serial No.	Stump height.	Girth at stump height. Under bark.	Four times radius. Inches*.	Sapwood measurements.		Number of rings for radius of																		*Total of four radii. Inches.	Total number of rings.	Remarks.
				No. of rings.	Average thickness. Inches.	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"	17"	18"			
1	..	..	96·1	..	..	33	56	74	92	115	135	157	178	201	226	..	..	..	..	..	..	..	..	96·10	..	
2	..	..	62·4	..	..	105	206	296	353	397	431	464	496	527	561	..	..	..	..	..	..	..	..	62·15	..	
3	..	..	84·6	..	..	41	69	93	112	135	162	187	216	248	285	..	..	..	..	..	..	..	..	83·50	..	
4	..	..	48·9	..	..	46	84	136	198	271	344	422	482	535	597	..	..	..	..	..	..	..	..	49·50	..	
5	..	..	65·3	..	..	64	122	189	253	314	356	397	439	492	545	..	..	..	..	..	..	..	..	68·00	..	
6	..	..	62·2	..	..	40	82	110	164	208	254	293	335	380	417	..	..	..	..	..	..	..	..	61·60	..	
7	..	..	76·3	..	..	53	88	114	150	184	218	253	291	333	365	..	..	..	..	..	..	..	..	74·10	..	
8	..	..	72·4	..	..	78	138	188	223	253	295	329	369	406	447	..	..	..	..	..	..	..	..	72·75	..	
9	..	..	76·2	..	..	49	77	109	135	157	180	203	228	254	277	..	..	..	..	..	..	..	..	76·15	..	
10	..	..	66·3	..	..	79	140	220	258	312	356	397	439	485	529	..	..	..	..	..	..	..	..	71·80	..	
	Total	..	710·7	..	..	588	1,062	1,529	1,938	2,346	2,731	3,102	3,473	3,861	4,249	..	..	..	..	..	..	..	..	715·65	..	
	Average	..	17·77	..	..	15	27	38	48	59	68	78	87	97	106	..	..	..	..	..	..	..	..	17·89	..	
	Adjusted	..	..	..	..	15	27	38	48	59	68	79	88	98	107	..	..	..	..	..	..	..	..	..	..	

* These headings were altered on the form to carry out the adjustment after averaging, *vide* last para. of the note.

UNIT MEASUREMENTS.

[Item 11 (a), (b), (d).
Stump Analysis Form No. 1.

Species. Cedrus deodara.
Quality. III.

Division. *Chakrata.*
Block and Compartment. *Mundali 2.*

Serial No.	Stump height.	Girth at stump height. Under bark.	Calculated average.	Sapwood measurements.		Number of rings for radius of																		Total radial length. Inches.	Total number of rings.	Remarks.
			Radius at stump height. Under bark in inches.	No. of rings.	Average thickness. Inches.	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"	17"	18"			
1	20"	..	..	..	..	8	14	19	23	29	34	39	45	50	57	..	..	..	..	..	..	..	..	..	..	
2	5"	..	..	..	..	26	52	74	88	99	108	116	124	131	139	..	..	..	..	..	..	..	..	..	..	
3	24"	..	..	..	..	10	17	23	28	34	40	46	53	61	70	..	..	..	..	..	..	..	..	..	..	
4	3"	..	..	..	..	12	21	34	51	69	87	107	122	135	151	..	..	..	..	..	..	..	..	..	..	
5	3"	..	..	..	..	17	32	49	66	82	93	103	114	128	141	..	..	..	..	..	..	..	..	..	..	
6	7"	..	..	..	..	10	21	28	41	51	63	72	83	94	103	..	..	..	..	..	..	..	..	..	..	
7	25"	..	..	..	..	13	21	28	37	45	53	61	71	81	88	..	..	..	..	..	..	..	..	..	..	
8	5"	..	..	..	..	20	35	47	56	63	74	82	92	103	113	..	..	..	..	..	..	..	..	..	..	
9	11"	..	..	..	..	12	19	27	34	39	45	51	57	64	69	..	..	..	..	..	..	..	..	..	..	
10	21"	..	..	..	..	22	38	59	70	84	96	107	119	131	143	..	..	..	..	..	..	..	..	..	..	
	124"	Total	..	..	..	150	270	388	494	595	693	784	880	978	1,074	..	..	..	..	..	..	..	..	..	..	
	12"	Average	..	..	..	15	27	39	49	60	69	78	88	98	107	..	..	..	..	..	..	..	..	..	..	
	Corresponding to diameters of				..	*2"*	*4"*	*6"*	*8"*	*10"*	*12"*	*14"*	*16"*	*18"*	*20"*	..	..	..	..	..	..	..	..	..	..	

Item 11 (a), (b), (d).]

Note on the use of 2 decimal place volume or sums of circles tables instead of 4 decimal place basal area tables for computing volumes, etc., of sample plots :—

Such tables are used in sample plot computation work for—

(1) Calculation of form factors of individual sample trees for drawing form factor curves.

(2) For calculating volumes of groups, and through them, the volumes of the whole plot.

At present, for (1) total volume and volume of cylinder of each sample tree is calculated to 4 places of decimals from which form factors are obtained to 3 places. For (2), the basal area of each group is calculated to 4 decimal places although for obtaining the average diameter of the group only 2 places (and sometimes 3) are required. With the diameter so obtained, heights and form factors are read from curves—heights to nearest whole foot and form factors to the nearest hundredth, although it is difficult to read more than a fifteen as each 1|10th of an inch is to be divided into 10 parts to get the 3rd decimal place correctly.

Basal area to 4 places is finally multiplied by form factor and height, and the volume to nearest 2nd place is entered on the form. It is to be considered now whether the methods of measurement are themselves so precise as to require such accurate tables for compiling the results.

The error in basal area due to diameter measurements which are taken to nearest tenths of an inch lies between .004 (for 8 ins.) to .013 (for 24 ins.) according to the size of the section, and the error in height is 0.5-ft. Therefore the total error in the volume of the tree is (.5 *plus* .004 to .013). Some of the errors in the basal areas of the individual sections may balance so that we may assume that the error in the total volume of the cylinder would be practically of the order noted above. Similarly in group calculations we read the heights and form factors from curves which have far greater errors in them than would be involved by tables of less accuracy. Further the volume tables recommended for use are not less accurate than the 4 figure basal area tables because they are the products of these 4 figure tables by lengths from which the nearest 2nd place has been taken.

For the sake of comparison of the two tables, 3 sample plots were worked out and the results are summarised below. Out of the 62 form factors calculated, 52 coincided, in 5 cases there was a difference of .001 and in the remainder a difference of .002 to .004 which however did not make any difference in the curves. The basal areas of individual groups calculated from usual 4 figure basal area tables when reduced to 2 figures agreed with the basal areas, calculated from these tables in 42 out of 51 cases and in the remainder the difference was .01 sq. ft. only. The crop volumes for the same sample plots were worked out by the two methods and the results are given below :—

Sample Plot No.	Av. diam. Ins.	Total basal area.	Timber.		Smallwood.		Method.
			Main crop.	Subsidiary crop.	Main crop.	Subsidiary.	
30 W. Almora ..	6·8	194·5	762	..	2,288	772*	Usual 4 place B. A. tables.
„ ..	6·9	194·5	763	..	2,287	739	2 fig. vol or sums of circles tables.
					Stem.	Total.	
19 L. Bushahr ..	20·5	411·2	17,788	..	689	944	Usual.
„ ..	20·5	411·2	17,789	..	689	944	2 fig. vol. or sums of circles tables.
					Total.		
46 L. Bushahr ..	5·7	104·1	109	..	1,794	..	Usual.
„ ..	5·7	104·1	109	..	1,795	.	2 fig. vol. or sums of circles tables.

An examination of the values in which a difference was obtained, particularly subsidiary crop of S. P. No. 30, W. Almora, showed that for getting correct diameter of groups to 1st decimal place an insight into the 3rd place of basal areas is essential in some cases and can always be got by carrying the division to the 3rd place and using the 3rd place figures for getting the average diameters for reading heights and form factors. If this were done in the above case the resulting volume would come to 772, exactly the same as by usual 4 figure tables.

It is therefore recommended that mean basal areas of groups be calculated to 3 places for obtaining corresponding diameters.

In the course of this investigation 2 figure basal area tables were also tested but they were found to be unsatisfactory.

Further it was discovered that in the present basal area tables obtained from Schlich's books, the 4th place of some intermediate values is wrong being usually rounded off to the lower value : thus for .47538 was taken .4753 instead of .4754.

These tables are superior to 4 figure basal area tables for the following reasons :—

(1) The shorter values can be used with greater ease and mean a great saving in time.

(2) It is not required to make double entries once for basal area and then for volumes which also saves time.—*M. A. Kakazai.*

* * * * * * *

Summary Note by Silviculturist, Forest Research Institute, on the Possibility of reducing regular Sample Plot work.

Three suggestions have been put forward :—

1. Omit interim measurements, going over to a 10-year-cycle whenever thinnings are not necessary at shorter intervals (Punjab, U. P.).
2. Drop out all plots which can be spared for species for which plots are numerous. (U. P.).
3. Take timber measurements over bark for all species for which bark thickness data are already available. (B. & O.).

The primary object of the interim remeasurement is a check that all is in order, experience having proved that this is essential for the proper maintenance of the plots. The secondary object, that the maximum amount of useful data shall be available at any date for compilation of yield tables or local working plans, becomes relatively unimportant for the half dozen species comprising the very big majority of existing plots. Under no conditions does it appear possible to leave a plot unchecked longer than about 5 years without serious risk that boundaries, numbers and cross marks will be effaced and unauthorised fellings made. Calliperіng the standing crop is highly advisable to ensure check that all trees are present, and numbers and crossmarks must usually be renewed. Other measurements are not essential, so that the work could be entrusted to a ranger. Teak tends to give more trouble than any other species owing to the rapidity with which number and crossmark are flaked off. Numbers can always be traced if the plot map is reasonably well done and the crossmark can be fixed by a nail exactly 8″ above (Field Rule 39), or by the scar left if the nail is removed. The proposal is therefore acceptable.

The abandonment of plots no longer essential is on the face of it a sound suggestion but one that should not be acted on if it can be avoided. There are grounds for dropping some plots which are unsatisfactory as such owing to uneven or incomplete stocking, disease or other abnormality and which are no longer necessary their place having been taken by other better plots, but no reasonably good plot should be dropped. Where it can be established that certain plots are duplicating information for the same age, quality and density, they are most valuable for studying different thinning grades and should be adapted to that purpose. Even if this is not done, some duplication is advisable as provision against loss from insects, fungi, fire, erosion, illicit or mistaken fellings and other dangers to which plots are exposed. Every plot with a recorded history over a period of years has a special value for a wide field of research work. While therefore there are good grounds for reviewing the future treatment of individual plots, only nonessential unsatisfactory plots should be abandoned.

Item 11 (a), (b), (d).]

The proposal to drop out under bark measurements on sample trees would reduce slightly the time required in a plot, but not enough to make any practical difference. Howard's bark thickness tables applied to the individual tree naturally show large discrepancies (average deviation of 8 per cent. for timber volume on examples tested), and though it might be argued that the use of general averages should even improve the final results as compared with present procedure, the necessary premiss is for a precision in the general averages equal to that of the rest of our sample plot work. Actually the available data for comparison are few as we have been measuring under bark only all the time, and to give a considered opinion, it would be necessary to accumulate several hundred measurements on the same trees and logs, both over and under bark. This could be done, but is it worth it ?—*H. G. Champion.*

(*Note.*—By an oversight this matter was not further discussed by the Committee or the Conference.—*H. G. C.*)

ITEM 11 (*c*).

Statistical Research in Irregular Crops.

Papers were contributed by the Silviculturist, Forest Research Institute (p. 202), by the United Provinces (p. 205), Madras (p. 209), Bengal (p. 212) and Assam. A committee consisting of Messrs. E. A. SMYTHIES (Chairman), C. K. HOMFRAY (Bengal), M. V. LAURIE (Madras), and E. C. MOBBS (United Provinces) considered these and drew up a report which was read and explained by Mr. SMYTHIES in opening the debate. The Central Silviculturist suggested one or two alterations in the committee report before it was adopted as part of the resolution, and after some discussion in which only the members of the committee took part, the following resolution was proposed by Mr. SMYTHIES, seconded by Mr. LAURIE and carried.

RESOLUTION ON ITEM 11 (*c*).

RESOLVED that—

The report of the committee be accepted as amended in debate.

Amended Committee report.

Papers describing the present methods and objectives of statistical research in irregular forests, most of which are mixed, were submitted by Assam, Bengal, United Provinces, and Madras, while a note by the Central Silviculturist summarised the results of the last (1929) conference and subsequent developments, and made suggestions for the future. These papers established the following points :—

(1) That there may be different objectives and therefore different methods of statistical research in mixed irregular forests, *e.g.*,

(*a*) A semi-botanical survey (Bengal).

(*b*) Data required by Working Plan Officers in prescribing the yield of a single species in mixed forests (U. P.).

(*c*) Data required by Working Plan Officers in prescribing the yield of several species in mixed forest (Madras).

(2) That there must be a clear definition of the objective before any such research is started. Only then can the scope and methods be decided, which must assure that the objectives are attained.

(3) That statistical research is at present chiefly required in mixed forests where only a few species (out of many) are exploitable. Yield tables for such forests are impossible at present.

(4) That long linear plots 1 or 2 chains broad and several miles long in each Working Circle or forest type appear to be the best form for such research, and the method of successive plot enumerations appears the only feasible method of collecting the required data either for botanical or working plan purposes. The enumerations should whenever possible, be made shortly before a main felling with a check after the felling has been carried out, and again shortly before the next felling. Interim measurement would serve to supply provisional data and another check after the second felling should be made if possible. The length of line must be sufficient to enable it to be safely assumed that the lines should cover the full range of conditions of the area. This is especially necessary where quality classes cannot be determined. The lines should be supplemented by compact plots 1—5 acres in extent in approximately pure patches of forest which come nearest to the theorical selection forest, these plots to be maintained as permanent statistical plots and treated under the selection system as defined in the glossary.

(5) That every stem (over a minimum diameter) of those species for which data are required should be measured and recorded by diameter or girth classes, and not only selected stems.

(6) That where Working Plan yield calculations are to depend on statistical research, the simplest possible objectives should be adopted to start with. It is for example useless for the Working Plan branch to ask for the *normal total growing stock* of one species in a mixed forest, but it is reasonable to ask for the *distribution of diameter* classes to sustain the present selection yield.

(7) That sub-division into quality classes, crown classes, canopy classes, etc., should, where feasible, be rigidly confined to the minimum required to

attain the objective, and all unnecessary elaborations excluded. In some types of forest, no such sub-division is feasible, *e.g.*, quality in moist evergreen. Over elaboration tends to make both the research itself and the application of results to Working Plans impracticable.

(8) That where some tree classification is considered advisable, the following shall be adopted :—

(*a*) Freedom of crown—(*i*) Dominant, (*ii*) Dominated, (*iii*) Suppressed.

(*b*) Size of crown—(*i*) Large, (*ii*) Medium, (*iii*) Small.

(8) That it is at present too early to try to standardise methods of analysis and application of results.

The Committee therefore recommends that the Central Silvicultrist be asked, in consultation with provincial research officers, to publish a note describing the technique so far developed in different provinces, with suggestions for methods of analysis and application of results in future. The Committee further recommends that as the subject is of importance to most provinces, co-operative investigations should be undertaken and the Central Silviculturist and provincial research officers should keep in close touch.

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PAPER (I).

By H. G. Champion, *Silviculturist, Forest Research Institute.*

The resolution passed by the 1929 Conference was to the effect that the note by Mr. Mahendru printed in the Proceedings should be circulated as a starting point for discussion, and that the Central Silviculturist should correspond with the provinces on the subject and submit a report to the next conference.

2. It cannot be said that any very marked progress can be reported, but a useful beginning has been made in the laying out of a large aggregate length of linear increment plots in Bengal, the United Provinces and Madras, and one aspect of the subject has been examined in some detail in connection with Mr. Smythies' papers on yield regulation (*Indian Forester* 1933, 1934).

3. For a determination of crop increment in unevenaged forest, the first method described was a *Yield Table Method* which is relatively simple but has not yet been tried out in India. It is largely based on crown space measurements. It is only applicable to pure crops of species for which age can be determined, though permanent sample plots could supply the needed increment figures in the course of an average felling cycle period. It would appear well worth trying out for *sal* in conjunction with other methods and for deodar selection working circles. A modification of the method was suggested for forests with the age classes collected in groups. A little work has been done in measuring, crown spread of *sal* (Bihar and Orissa) and deodar (Research Institute).

4. The second method is based on *Stem analysis* and is applicable to mixed forests such as the important teak bearing forests. Increment is determined by stem analyses which may be worked up on a diameter basis only, or on a diameter and age basis—*Growth Charts*. Determination of mortality remains a difficulty and can at present only be estimated ; the predictions of increment for the probable extreme range is compared and a conservative estimate adopted. This method is more or less the one commonly followed, but the field work generally falls far short of requirements being unsystematic particularly as regards selection of sample trees for analysis, and mortality data.

5. The third method is that of *Successive Plot Enumerations* which has the advantage of giving actual crop increment data but the disadvantage of requiring a long time for results. Crop increment is compared for different basal areas and diameter class distribution, and the conditions for optimum growth determined practically by trial and error, usually by formulating an hypothesis on general grounds and testing its correctness. This is the method of Biolley and his school and has not been applied in India. It is doubtful whether we have the right conditions for it but we should consider its possibilities.

6. The fourth method relies on a determination of the *Growth percent* of each diameter class from increment borings or stem analyses, and is really only a different form of the *second method.* It has not so far been adopted to any extent in India.

7. These methods having given crop increment, it remains to determine what relation to it the yield to be realised should bear, and this necessitates

some standard for *Normal Stocking* both as regards total volume and diameter class distribution. The note pointed out that normality implies that distribution of diameter classes which produces the highest qualitative and quantitative increment consistent with a sustained yield, and the normal growing stock must be that in a fully stocked forest which produces such a sustained yield. The only suggestion made for collecting information on both these points was by averaging results from permanent sample plots selected as appearing nearest to requirements in both respects.

8. At present there is a reaction from evenaged and usually single species regeneration back to the unevenaged form even in intensively worked forests. It is possible that a solution of regeneration problems and developments in the use of species mixtures may again alter the position, but the fact will remain that for at least half a century the greater part of our forests including many accessible areas from which the maximum outturn is required, will not have been converted and will have to be managed as unevenaged crops. We ought therefore to expend a more or less corresponding proportion of our research efforts on their problems provided there is a reasonable prospect of practical results.

9. The first requirement is for more data to go on. We must have reliable information as to the present structure of representative forests of the type in question and adequate details of their growth. The difficulty—it is not too strong to say impossibility—of selecting compact plots which could be accepted as true samples of a whole felling series, has led up to the adoption of the linear plots, usually 1 chain wide, for these studies. The first such plots were laid out in Bengal from 1923 onwards aiming at having one or more lines through each of the important ecological types. Last season, the United Provinces has laid out 13 miles of line in *sal* selection forests. The project in the latter case was for the local staff to indicate compartments considered most representative and the research staff to lay out the line on a compass bearing straight through them, measuring area and trees much as in a standard sample plot. Where possible the lines were to be made in compartments already marked for selection fellings ; remeasurement was to follow the actual felling and again to precede the next felling, probably with one interim measurement. Measurements were recorded separately for each running chain, and ultimate analysis of the line into types or qualities was anticipated Combining the experience reported from the several provinces interested the following points have arisen.

10. *Tree Classification.*—The standard classification for evenaged crops is inadequate for irregular crops, primarily owing to the initial classification of canopy layers based on height ; it is true that if crop height is taken as determined only by the trees in the immediate vicinity of the tree to be classified, the same system should be applicable, but there is a feeling that this is too subjective a method. We should therefore drop out all reference to height and refer only to the freedom of the crown as :—

Dominant, with leading shoots free from overhead or near side shade ;

Dominated, with leading shoots free but with near side shade from taller trees ; and

Suppressed, with leading shoot definitely overtopped or with near side shade from taller trees on all sides.

In many groups, a classification of the *Dominants* into *Predominant* and *Codominant* will appear practicable, and as for evenaged crops, it may be desirable to differentiate for research purposes. Then *Predominant* would comprise the tallest trees in any group, free from vertical competition, and *Codominant* would comprise dominants which though free are in close proximity of predominants.

Size of crown is the other important factor in determining increment. Detailed subdivision only results in complicating analysis, so that simple differentiation into (*a*) Good, (*b*) Medium, (*c*) Poor, is recommended. Many authorities would further have us add a bole classification, perhaps by quality grades exactly as for crown size, and it might be as well to record it to permit of later analysis if called for. SCHADELIN (1) has recently recommended such a classification with a simple decimal rotation (thus 2. 1. 3=dominated with good crown and poor bole), and come in for a spate of facile criticism from

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(1) **Schweizerische Zeitschrift für Forstwesen, 1931 p. 1.**

Heck and others. A classification of this kind was tried in the Madras tropical evergreen with satisfactory results. An enquiry addressed to the leading Central European Research Institutes failed to elicit any helpful suggestions on the subject.

11. A further point which arises and has sometimes been stressed, is that with selection felling, sudden and complete changes occur in the growth conditions of the individual tree unparalleled in the regular forest, and response must vary with the age and past history of the individual tree. This can hardly be disputed but in practice must be considered as part of the normal life of the selection forest to be met in statistical studies by collecting a sufficiently large number of data to derive mean values.

12. To determine the *size of the samples* required for study, it is necessary to consider the practical application of the anticipated results, and the details of the analysis called for.

It is evident that if complete analysis by tree classes is required, we should need in our plots a minimum of 3 dominance classes, *times* 3 crown classes, *times* say 8 diameter classes, *times* say 3 locality classes or types, *times* 10 trees, or 2,160 trees for each species. Actually if a similar figure is computed for evenaged *sal* forest from yield tables taking half acre plots for each decade (20 to 100) in three qualities omitting crops under 6″ diameter, the number comes to 2,200 trees, whilst with over 250 sample plots there must be some 14,000 trees under observation. In working up to the minimum of 10 trees per ultimate analysis unit, the actual number of trees in the plots would of course be several times greater, but it can be demonstrated that provided the most important classes are adequately covered, a shortage in the others is not serious. Thus, the increment of, say, the dominated poor crowned trees could be estimated for all diameters together by determining its percentage relationship to the dominated medium or dominated good crowned trees. Experience may well prove that for practical purposes it would be best to refer all increments to the standard of the D (*a*) trees so that if a sample enumeration showed 15 per cent. of dominated trees and the research plots had shewn that the average *d* tree lays down 50 per cent. of the average increment of the D(*a*) tree, the average increment in a felling series would be $\frac{1}{100}(85+\frac{15\times50}{100})$ of the standard D(*a*) figure.

13. The analysis of the data of the linear plots into types or qualities is presenting difficulties. It would appear that some sort of statistical analysis should be possible, but none has yet been devised. It seems that this will have to be done at least for the present by direct observation of the associated vegetation combined with a record of maximum height, but an intensive study by a trained ecologist ought to provide means of improving on this and should be taken up. It is evident, and is borne out by experience, that the linear research plots can never provide a true sample of a felling series, forming far too small a proportion of it, and their proper function must be to supply basis data after analysis.

14. The effect of *density* on increment requires further study particularly as we have very little data even for regular crops. Conditions are obviously very different in the typically open deciduous forest and the dense many storeyed wet evergreen. It may, however, turn out that this factor is sufficiently provided for in the tree classification.

15. Reverting to the conception of the *Normal Selection forest,* the need of a standard to work to is experienced directly the problem of yield regulation is faced. The ideal distribution of diameter classes appears as more important for immediate practical purposes than the growing stock per 100 acres. There are no Indian data to go on and the only point that is clear from European publications is that the higher diameter classes must be proportionately much better represented than in regular forest. Unfortunately there is no answer to the question, how much better ? In correspondence with Mr. Smythies, I summarised the indications of European forestry as requiring in selection forest nearly ten times as great a proportion of top diameter class stems as in regular forest of the same quality, and only about one-third the proportion of third class stems [I : II : III = 1.0 : 1.0 : 1.25 for selection forest, and 3.3 : 1 : 0.13 for equivalent regular forest]. Flury* (Swiss F. R. I.) has contributed perhaps the most important recent survey of growth conditions in selection forest.

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*Mitt. Schw. Ans f. d. forstl. Vers. XVIII (i) II 1933

16. This leads to the question, can we look to get light on this point from an analysis of data from the linear plots ? I think the answer is that whilst it is likely that on an adequate aggregate length of line of the selected type, the big marginal effects will cancel out, we should feel more confidence in a larger compact plot. I therefore recommend that a look out should be kept for areas of an acre or two along the line where the forest appeared reasonably uniform in quality and of the true selection type with most age and diameter classes adequately represented. Such areas should be constituted permanent sample plots for studying the relations between growing stock, felling and increment, regulating the fellings on a special project designed to give predetermined proportions of the broad diameter classes, and watching the effect on the increment.

17. Information concerning *mortality in recruitment* of the upper diameter classes is also essential for yield regulation and both the linear plots and the suggested compact plots will supply the required data in due course.

Recommendations for further research work are as follows :—

(1) Laying out linear plots on lines adapted to the conditions prevalent in each important type of forest—*Sal*, mixed deciduous, wet evergreen—of length adequate to cover the important range of quality or subtypes, diameter and tree classes as required for analysis. The lines should be laid out shortly before a selection felling is done, and should be remeasured after the felling, and again after the next felling is marked. They would probably be maintained for at least one further cycle.

(2) Supplementing the linear plots with compact blocks 1—5 acres in forest which comes nearest to the theoretical selection forest, treatment being devised to study the relation between increment, proportional representation of diameter classes and total growing stock.

(3) An ecological study of the vegetational variations on these lines and plots, with a view to the recognition of a small practical number of growth types for the chief species, and analysis of the growth data by types.

(4) The adoption of the sample tree classification given above for these studies.

(5) Studies on actual examples by the Central Silviculturist of the yield table, growth chart, and growth percent methods in representative forest types with a view to determining their practicability and value for Indian forests.

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PAPER (11).

By E. A. Smythies, *Conservator of Forests, Working Plans and Research, United Provinces.*

The United Provinces have recently embarked on an extensive programme of statistical research in the 1,000 square miles or so of irregular hill *sal* forests, the principal object of which is to collect data for applying the new selection yield control method. As a preliminary, therefore, a brief description of this method may prove useful. I intentionally omit all reference to mathematical formulae and calculations which have already been published in the *Indian Forester.*

The average size of a Working Circle in these hill forests exceeds 100,000 acres. The crop varies from pure *sal* to pure dry deciduous miscellaneous, a hotch-potch of different types often varying every few chains. From the dawn of scientific forestry these extensive areas have been managed with selection or exploitation fellings of trees over exploitable diameter and a felling cycle. No other system at present seems conceivable. With a felling cycle of 15 years, the average annual coupe in a Working Circle is about 7,000 acres. Only large size *sal, sain* (*Terminalia tomentosa*) and *haldu* (*Adina cordifolia*) are saleable species.

The problem we have to face is to regulate the rate of removal of the first class or selection trees (*i.e.*, over exploitable diameter) so that there will be at least an equal number available at each cycle. For the first 40 or 50 years,

Item 11 (c).]

Brandis's method of yield control was universal. This fixed the number of trees to be felled annually over prescribed area coupes. It required data of :—

(*i*) total growing stock of I and II class trees.

(*ii*) the ratio between I and II class trees.

(*iii*) the factors *t* and *z* of my formula (see Mr. Mobbs' note).

For the last 15 or 20 years, there has been no limitation on the removal of selection trees, but Working Plans encouraged the removal of all that were silviculturally available. We have now clearly realised that our forests cannot stand this rate of felling at present, and we must have some mathematical limitation on the rate of removal of selection trees. The basic idea of the new control is the same as with Brandis, namely, that the I class trees removed will be replaced by recruitment from the II class trees during the felling cycle (plus or minus adjustments for abnormal conditions of stock), but there is one important difference. Our selection control prescribes, not a number of trees (as the Brandis method did) *but some simple percentage or fraction of I class trees found in the area coupe of the year by the marking officer,* usually 1|3rd, or 2|5ths, or ½ or 2|3rds, so that the marking officer has a very simple prescription to follow. It is a more important change than appears at first sight, since it avoids the necessity of knowing the total growing stock. So long as we know the ratio between I and II class trees, we do not need to know their totals. We can ascertain this ratio more accurately with a smaller scale of enumeration than we can ascertain the total growing stock with complete enumerations, and Mr. Howard, recognising this, agreed to a saving of Rs. 15,000 this year in my Circle budget by reducing enumerations for two Working Plans under revision. It is thus a point of considerable practical importance.

This selection yield control has definite advantages over Brandis, or similar alternatives, *i.e.*,

(*i*) it reduces the scope and cost of enumerations and working plan revisions.

(*ii*) it tends to eliminate or materially reduce errors of enumeration, since an estimate of the ratio of II : I will usually be more accurate than an estimate of total growing stock, *i.e.*, II + I.

(*iii*) it gives a simpler prescription for a marking officer to follow, and he knows all the time whether he is diverging from the working plan prescription or not. With a volume yield and fixed area coupes, he is never certain how he stands until he finishes.

It will have been noted that we have to assume values for *t* and *z*, and as we have no other data whatsoever, we base these values at present on yield table figures for regular fully stocked crops. We believe that *z* (almost certainly) and *t* (probably) will be conservative when applied to partially stocked irregular crops. But we want reliable data applicable to irregular mixed forest, and the programme of statistical research we have recently started is definitely aimed to give us those data.

Mr. Mobbs's note explains in detail the procedure that he has recently evolved. Points for consideration of the conference will be :—

(*i*) Will that procedure give us the data that we want of *t* and *z* (*i.e.*, diameter increment and wastage) for each diameter class in these very irregular and variable forests ? To guarantee proportional representation of every type is recognised as impossible.

(*ii*) Can we aim at getting anything more than this by statistical research in these forests ?

(*iii*) Should that procedure be modified or improved in any way ? Are any of the measurements and records now being made unnecessary and avoidable, or should some others be added ?

(*iv*) If we record data under various heads such as quality classes, diameter classes, crown or tree classes, etc., to what extent can we utilise all these sub-divisions of data finally ?

(*v*) How far will it be possible to standardise procedure between provinces, so as to get comparable results in future for similar conditions ?

[Item 11 (o).

PAPER (III).

By E. C. Mobbs, *Silviculturist, United Provinces.*

(*i*) *General.*—A very large part of the *sal* forests of the United Provinces must be classed as irregular ; the extensive areas belonging to the moist and dry Siwalik types from the Dehra Dun to the Haldwani divisions must probably always remain irregular, while the failure to obtain adequate regeneration in many other areas under "Conversion to Uniform" management is making it necessary to regard and treat them again as irregular forests.

The general history of and recent developments in the management of the *sal* forests of the United Provinces have been described by Mr. Smythies in several articles of the *Indian Forester*,—notably in the April 1932, and the June, July and October 1933, issues. The last two articles dealt more particularly with the new "Safeguarding Formula" that has been evolved for the management of all the irregular *sal* forests. The formula is perhaps only a make-shift, but for practical purposes it is at any rate a good one, and it has also served a very valuable function in indicating the general lines on which statistical research into the irregular *sal* forests might in the first instance proceed.

A minimum selection, or more correctly exploitation, diameter is fixed, and the number of trees above that diameter which may be felled annually is determined by the number of trees that are annually passing above that diameter from the diameter class immediately below it. The primary formula is :

$$X = \frac{f}{t} \quad (y - z).$$

X = the number of exploitable trees that may be felled annually,

f = the number of years in the felling cycle,

t = the period of years for the diameter class immediately below the minimum exploitable size to pass into the exploitable class,

number of trees in the diameter class immediately below the minimum exploitable size,

percentage of y trees that disappear (by thinnings or otherwise) in t years and do not come into the exploitable class.

This primary formula thus limits the removal of exploitable tree to the number that actually pass up into the exploitable class from the diameter class immediately below. At the end of t years, there will therefore theoretically be as many exploitable trees in the forest as there were to begin with, and an equal sustained yield is assured for a period of at least 2 t years.

It may be that the exploitable trees are in excess or in deficit to begin with. The primary formula is therefore modified to :—

$$X = \frac{f}{t}($$

where A is the number of exploitable trees that are to be removed annually in addition to the calculated yield to reduce a surplus, or conversely the number by which the calculated yield is to be reduced to make up for any deficiency in the exploitable class.

In this formula, f is fixed for each working circle on general considerations, and y is determined by enumerations over the whole circle. The enumerations also give the existing number of exploitable trees, and A is fixed somewhat arbitrarily on considerations of the general distribution of stocking. But t and z remain unknown quantities and for the time being are guessed at for irregular *sal* forests on the basis of existing data for regular forests. Some form of immediate statistical investigation was required to determine the value of t and z for all sorts of irregular *sal* forests, and if possible to give some basis for a reasonable determination of A, and to provide whatever further statistical information it was possible to obtain within a reasonably short period of time.

(*ii*) *The Linear Sample Plot.*—To obtain the required information for the "Safeguarding Formula" it was decided to lay out a series of Linear Sample Plots or perhaps they should be more correctly termed Linear Increment Plots—in all the main types of irregular *sal* forest. A start was made with the Moist and Dry Siwalik Hill Sal ; 8 miles of lines have been laid out in the former and 5 miles in the latter. It is proposed to continue the work in the same types and to extend it into the Dun and Bhabar (High Level Alluvium) type, and possibly later on into other types.

Item 11 (c).]

One of the main objects of having lines at all is to get representative samples of all sub-types, and if one could have a sufficient length of lines, it would be unnecessary to select areas for them. As, however, practical considerations limit the length of lines that can be laid out, and as there is a great variety in the number and distribution of the sub-types in any one general type, it was at once necessary to select duly representative areas for the lines. It was impossible for the Silvicultural staff do this, and representative compartments for the lines were therefore selected by Working Plan Officers, in consultation with the Conservator, Working Plans and Research Circle. The compartment and general direction of the line having been given, all the rest of the work has been done by the silvicultural staff. The lines certainly include almost every possible sub-type : this will be evident from the photos of some of the lines included in the set of U. P. photographs for 1933|34 now under circulation. There are patches of pure *sal* poles and of mature *sal* ; uneven aged *sal* pure and mixed with other species ; II, III and IV Quality sal ; areas with bamboos, asna and other species and only a few *sal* ; almost pure *bakli* (*Anogeissus latifolia*) crops ; and so on. What is not certain, however, and can never be certain, is that the proportions of these sub-types is more or less the same as their proportions in the main types as a whole. Since the *sal* in the various sub-types has very obviously different growth rates, there might be serious objection to the application of any general results to the type as a whole. But it already seems necessary to adopt a different exploitable limit for different quality classes of *sal*, and it will therefore be necessary to calculate the values of t and z separately for different quality classes, as well as for the type as a whole, and it will rest with Working Plan Officers in the future to determine which values they will adopt. This aspect of the problem is not perfectly clear, and any help or suggestions that the Conference may be able to give will be welcomed.

The general method laying out the lines is as follows :—

The line is 1 chain wide, measured along the slope and the length may vary from 1 to 3 miles, according to locality, usually going in one direction across one, two or more compartments and starting and ending at a convenient place, such as a *nala*, fireline, ridge or path. The centre of the line is laid out by prismatic compass and is marked on the ground with stout numbered wooden pillars, roughly at 8 to 10 chains intervals, the actual distance, measured on the slope, being recorded, and the positions depending chiefly on the nature of the ground. Where necessary, intermediate stone pillars are erected. Where stones are not available, the numbered posts are placed closer, at 4 to 5 chains intervals. The centre of the line is also roughly marked with rings of white paint on trees, but for future work it has been decided to mark the marginal included trees with white paint rings, and not the centre ones, in order to know at subsequent measurements which miscellaneous trees have been included.

For each square chain (along the slope) the Type (moist, medium or dry), Quality class, Aspect and Gradient (along and across the line) are recorded. Quality is determined by height and diameter measurements, the height-diameter curves for regular *sal* forests being used. No fixed rule is made as to how many heights are to be taken, but they are taken as frequently as practicable, and may include trees in or immediately adjacent to the line, and they are invariably taken whenever there appears any change in quality.

Sal, *asna* (*Terminalia tomentosa*), *haldu* (*Adina cordifolia*) *chir* (*Pinus longifolia*) and *semal* (*Bombax malabaricum*) are all numbered if over 8" diameter, small metal plates being used nailed at 5' 6" above ground level on the upper side of the tree. The tree is then measured at exactly 1' below the nail, *i.e.*, at 4' 6". Trees below 8" are not measured, but record is made as to whether such trees are numerous or not in the square chain. Trees of all other species over 8" are measured and recorded, but are not numbered. Every 100th numbered tree is marked with 2 rings of white paint and the 1000th with 3 rings (so far no line has as many as 1000 numbered trees). Diameters are measured at right angles to the nearest 1|10th of an inch not because such accuracy is necessary for the purpose of the " Safeguarding Formula ", but to ensure an ultimate acceptable accuracy to the nearest inch or half inch. In addition the crown class of each numbered tree is recorded. This matter is dealt with later.

It has not yet been possible to analyse the data collected in the lines laid out this year, and in any case the main analysis will not be made till subsequent remeasurements, which it is proposed should be made in 5, 10 and 15 years' time, when one felling cycle will have been completed, and every line will have felled over. When the fellings are made, they will be made in the lines in exactly the same way as in the rest of the compartment.

Both t and z can only be determined after the remeasurements. From the initial measurements the trees will be divided into diameter classes, and from subsequent measurements it will be known how many trees of each class have passed up into the next class, and also how many have disappeared in the interval. It will also be possible for the various quality classes to determine the increment-diameter relationship for the irregular *sal,* but this is likely to be only an average between very widely varying limits, unless the data are separately analysed not only for the different quality classes, but also for the different crown classes in the same quality class, since trees in the same diameter class will include all conditions of dominance and suppression. And even if this be done, there will be considerable variation of increment in the same crown class, owing to the difficulty of correct crown class classification in such varying forest. For the time being, it would appear advisable to classify the initial data for each quality class into diameter classes, and into crown classes within each diameter class, so that the information is available for subsequent use if needed.

Since the gradient along and across the line is measured for each square chain, the actual horizontal area can be calculated. It is thus possible to obtain the actual area occupied by each quality class, the area with some *sal* and the area completely without *sal* (or other numbered species). It is also possible for each square, using data for regular forests, to obtain the total basal area and total volume of *sal* (or all numbered species) and to calculate for each quality the average basal area and volume per acre. This, however, would involve very considerable compilation work, and I am not sure that the information would be worth the labour involved. The volume calculations would also necessitate rather considerable assumption regarding the volumes of trees of different crown classes and the same diameter, or else a comprehensive series of volume determinations for different crown classes, which for the present would be impossible.

(*iii*) *Tree classification.*—Considerable difficulty was experienced in following the Forestry Commission tree classification approved by the Silvicultural Conference of 1929. In an irregular forest, especially of the Siwalik Hill Sal type, the effect of past fellings, the quality, the ages and the admixture of other species all vary so frequently that it appears wrong to fix the canopy class of the trees on the basis of the heights of the dominant trees, unless one's standard of dominance is to change with every square chain, which is inadvisable. After much discussion and trial in the field, it was finally decided to revert to the old system of classification, *i.e.*, into 3 classes—Dominant (D), Dominated (*d*), and Suppressed (*s*), the first two being sub-divided into D-1, D-2 and *d*-1, *d*-2 according to the nature of the crown. Even so, much has to be left to discretion as it is often obvious that an apparently dominant tree was formerly badly dominated or suppressed by a much bigger tree that has been removed in past fellings.

(*iv*) *Miscellaneous.*—The average cost of laying out the lines was roughly Rs. 80 per mile. This included some very difficult and steep country.

PAPER (IV).

By M. V. LAURIE, *Silviculturist, Madras.*

General.—A start has been made in Madras at collecting information regarding the girth increment of trees growing in irregular mixed forest, but the problem of applying the data, and hence the best methods of classifying the trees measured has not been properly thought out, and presents some difficulty.

2. *Definition of purpose.*—The purpose of these investigations is to acquire reliable data regarding the girth (or diameter) increment of trees in irregular crops which can be applied to working plan enumerations for making accurate calculations of the yield.

3. *Work done so far.*—A number of linear tree increment plots have been laid out in different types of forest (Evergreen Rain Forest for *Hopea,* "

Palaquium and *Calophyllum*. Mixed Deciduous forest for teak, *Terminalia crenulata, Lagerstroemia lanceolata, Grewia tiliaefolia,* and *Xylia xylocarpa* and Dry Deciduous forest (Red sanders type) for *Pterocarpus santalinus*. The trees within one chain of well known paths are marked and mapped and diameter measurements at breast height taken periodically according to the instructions in the Statistical Code. Methods of crown classification, etc., have not been finally decided upon.

4. *Application of results.*—Before it is possible to decide the best methods of crown classification, etc., it is necessary to consider how the results are to be applied. It is assumed that the plots have been selected so as to cover the whole range of quality and geographical distribution to be studied and that the plots are typical of the forests as regards uniformity and density, and that they will give diameter increment data for trees of every crown and canopy class. The Working Plans Officer will have enumerated his forest and measured diameters throughout. Since the increment plots, though covering the whole range of qualities and sub-types under consideration, are not likely to be representative of the whole forest ; the data given cannot be applied direct to the various diameter classes, and some further classification into crown and canopy classes appears to be necessary. Thus the trees will be divided into :—

(1) Quality classes,

(2) Canopy classes,

(3) Crown classes,

(4) Diameter classes.

The Working Plans Officer would therefore have to differentiate quality classes and enumerate them separately and also determine the proportions of the different crown and canopy classes in each girth class for each quality in sample strips in his enumeration, the classification adopted being the same as that used in the increment plots themselves. This appears to be a rather complicated and laborious procedure, and perhaps the Conference can suggest some method of simplifying it.

5. *Selection of increment plots.*—Rules for this have already been laid down in the *Statistical Code* [Page 44, iii b (*a*)]. A difficulty is encountered in mixed deciduous forest where the type changes rapidly from open areas with well spaced trees and much *Lantana* and growth of small trees, to fully stocked portions with many trees per acre, and further to dense bamboo forest with few trees per acre. It would appear to be impracticable to differentiate these types which may change within a few chains, and the only remedy appears to be to have larger increment plots in as typical areas as possible so that the different types are represented proportionally. There may be some error in applying the data to a portion of forest in which the types are represented in different proportions but it is difficult to see how this can be overcome in a practical manner.

6. *Selection of trees.*—It is necessary that a sufficient number of trees of each diameter, crown and canopy class should be measured. Criticism was made of some of the plots in Madras that subjective selection had been made, and this was obviously the case in one deciduous forest tree increment plot where the trees selected were all good " normal " trees with straight boles and good form, whereas a large number of the trees were crooked, or swollen at the base, or had some other abnormality. Since such abnormalities would not be considered as reason for rejection in a working plan enumeration they should not be omitted in a tree increment plot. Such subjective selection can be overcome by marking and measuring every tree of all sizes and conditions that would be enumerated for a working plan, but this on the other hand might introduce an unnecessarily large number of certain sizes and classes. In order to keep the work down to a minimum, excess trees in such classes should be rejected but it is important that such rejections be made mechanically on paper, since the eye cannot be trusted not to make a subjective selection of such trees on the ground.

In Example 27, Page 44, of the *Statistical Code*, it is stated that " For normal increment in uneven aged forest it is a matter for consideration whether only trees likely to reach rotation age or exploitation size should be taken or a sample of all trees found ". Since the data are to be applied to working plan enumerations in which no such selection of trees likely to reach rotation age is made, it seems necessary to take representative samples of all trees in each diameter class whether they are likely to reach rotation age or not. It seems necessary, moreover, to take a large number of trees in the lower diameter classes in order to allow for trees falling out owing to suppression or to becoming so unsound as to be not fit for enumeration. All this points to the advisability of taking all trees in a plot and not merely equal or graded numbers of trees in the different diameter classes.

7. *Crown and canopy classification.*—In order to reduce as far as possible the number of classes into which the Working Plans Officer has to sub-divide his enumeration it is necessary to make the canopy and crown classification as simple as possible. The system given in the Statistical Code for regular crops has been found difficult of application in mixed forest where all height classes are mixed up together.

In open Red sanders forest (*Pterocarpus santalinus*), there is little need for crown classification since every crown is separate and would be called " D. 1.a " according to the system used for evenaged crops.

In evergreen forest with a definite top canopy a simple classification was found to be :—

I. Crown with full overhead light,

II. Crown with restricted overhead light,

III. Crown with no overhead light, each of these being subdivided into

(*a*) Full sized crown for the size of the tree,

(*b*) somewhat constricted crown for the size of the tree,

(*c*) badly constricted crown for the size of the tree.

This classification was found easy to make on the ground, and different observers soon acquired the same standards of judgment after a little coaching. When, however, it is considered how this classification is going to be applied, one is a little horrified to find that 9 different increment figures would have to be worked out for each diameter class in each quality, and the final table might consist of say three qualities each with about eight to ten diameter classes each with nine crown-*cum*-canopy classes—or a total of about 240 classes for each species into which the Working Plans Officer would have to divide his enumerations. Some simplification appears to be necessary though it is difficult to see how the scheme suggested can be made simpler than it is unless some of the classes can be combined in some way or other. The suggested classification involves, moreover exceedingly unwieldy increment plots, since in each of the 240 classes it is necessary to have a sufficient number of trees to give a reliable point on the curve of averages. The Central Silviculturist could probably say more definitely what number would be required, but I imagine it would not be less than 10 to 15 trees which would mean that at least 2,400 to 3,600 trees would have to be measured in each plot.

In mixed deciduous forest the question of crown and canopy classification is complicated by the irregularity of the canopy and the rapid variation in type of growth encountered. There are always a number of gaps of varying sizes caused by selection fellings, wind-falls, flowered out bamboo clumps, etc., which have not filled up on account of dense invasion by *Lantana* or from other causes. The canopy is so irregular in density and height that the ordinary classification by dominance and crown condition as prescribed for regular crops is obviously inapplicable. One finds, for instance, a number of trees half or two-thirds of the top canopy with completely free crowns and not dominated at all, which would not fit in to the usual classifications.

The classification suggested above for evergreens might be used though the conditions of dominance are very different and the variation in crown size, especially in the smaller diameter classes, is very much greater.

Another difficulty in mixed deciduous forest is the presence of bamboos with their periodic flowering and consequent complete change of the conditions of dominance in cycles of about thirty years. It is difficult to see how it would be possible to collect and apply reliable increment data in such forest.

Summary.

The general problem has been briefly stated and methods of crown classification in evergreen and deciduous forests suggested. It is required to decide from the point of view of application of results to working plan enumerations, and of simplifying the work as far as possible what methods of crown classification are likely to be the most practicable for different types of forest, and rules require to be drawn up for inclusion in the *Statistical Code* regarding the classification of the data collected, the working out of increment figures and their application to working plan enumerations. The rules should also specify the data that have to be collected in the course of such enumerations in order to enable the increment figures to be accurately utilised.

It might also be discussed whether any practical method for collecting and utilising increment data for trees in bamboo forest can be devised.

PAPER (V).

By C. K. HOMFRAY, *Silviculturist, Bengal.*

Linear Plots were started in Bengal in 1923 by Mr. E. O. Shebbeare, then Silviculturist, and up to the present 17 lines totalling approximately 15 miles have been laid out by the Silvicultural Branch. Lines have been laid out in the following major forest types—foot-hills miscellaneous, plains *sal,* deciduous *Dipterocarps,* and *mangrove* forests. Lines are marked on the map at random and laid out on the ground afterwards ; this prevents any attempt to select the best areas which might be the case if the lines were selected on the ground. The width of the line is one chain and the length may vary from 1½ to ½ a mile until it reaches a convenient boundary. The lines are laid out by compass. A line 2 feet wide is cleared of all undergrowth and it has been found that this line is always kept clean as the jungle animals use it for a path. Every tree of 4″ diameter and over at breast height whose centre occurs within the ½ chain on either side of the centre of the path is numbered with a tin plate and the point of measurement marked with a cross in white paint at 4′—6″. The cross and number plate are always put so as to face the path. Trees under 4″ diameter are ignored. No undergrowth is cut except in 2′ centre path. A stake with the number of the chain painted on it, is struck in the centre of the path at every chain length of the line, and a line drawn in the note book showing the number of the chain. Any change in the type of forest is noted in the note book and the length of the line noted where it begins and ends. Diameter measurements are taken every 5 years.

The results supply otherwise unavailable data as to the composition, qualitative and quantitative, for every type and sub-type of forest. Unknown species and those of doubtful identity are easily marked down and specimens sent to Dehra Dun for identification and we may say that in the forests where these lines occur there are hardly now any un-identified species left. They give authentically determined trees for seed and specimen collection and for observations on seeding, natural regeneration, etc. By periodic diameter measurements some idea of the rate of growth of the less important species can be ascertained which at present is practically unknown. Parts of these lines sometimes fall into the annual clear-felling coupe and in such cases all trees to be felled are measured up for volume data.

Interesting facts are collected as to the mortality of certain species and also when certain fuel species such as *Macaranga* and *Machilus* spp. reach maturity and put on no further growth.

In addition some of the older lines have been relaid and any trees that have reached 4″ diameter at breast since the line was first laid out were included and numbered and measured. This is of great interest and shows exactly how the constitution of the forests is changing under fire-protection. Even in the dry mixed forests the most common trees that are coming in were found to be *Dysoxylum* spp., *Amoora wallichii, A. rohituka, Chisocheton paniculatus, Meliosma simplicifolia, Cryptocarya* spp., *Casearia* spp., *Pithecolobium angulatum.*

Linear plots can be very advantageously combined with the
Plots and this is being done in several instances in Bengal.

Report of Debate.

Mr. Smythies.—Tucked away under the rather innocent looking heading of "Agenda and corrigenda to the Statistical Code", we seem to have one of the most important and one of the most difficult subjects for discussion before this conference, namely, statistical research in irregular crops : important because it applies probably to 75 per cent. of the forests of India from Cape Comorin to the Hindukush, from tropical evergreen to high level conifers. In the proceedings of the last silvicultural conference, we may read a note that "no paper was submitted on this subject, but this was due more to the inherent difficulties of the problem than to lack of interest and it was suggested that a report should be submitted to the next silvicultural conference". I hope we shall be able to go a step further at this conference.

Mr. Champion when he suggested to me that I might take up this subject for introduction at this conference and put up a summary of the papers received, remarked that there was no published literature anywhere in the world to help us to tackle the problem and that we should have to work out our own salvation from the beginning. I think that is in some ways an advantage because we start with a clean slate and can write whatever we like on it.

The statistical problems relating to irregular forests are as old as the Forest Department in India and they apply on a much larger scale than the problem relating to regular forests. The latter only began to be systematically studied about 25 years ago with Troup's pioneer work and everybody knows the remarkable progress that has been made in those twenty-five years. I think we are now in much the same position in regard to regular crops, that is to say, at the dawn of systematic study.

A committee was appointed to consider the papers which were submitted on this subject and they have prepared a report which I will place before the conference. This report contains seven or eight points and it will probably simplify matters if I deal with each point and discuss it separately, giving the reasons which led the committee to make their proposals on it. The report of the committee is as follows.

Report of the Committee.

Papers describing the present methods and objectives of statistical research in irregular mixed forests were submitted by Assam, Bengal, the United Provinces, and Madras, while a note by the Central Silviculturist summarised the results of the last (1929) conference and subsequent developments, and made suggestions for the future. These papers established the following points :—

(1) *That there may be different objectives and therefore different methods of statistical research in mixed irregular forests, e.g.,*

(a) *A semi-botanical survey (Bengal).*

(b) *Data required by Working Plan Officers in prescribing the yield of a single species in mixed forests (United Provinces).*

(c) *Data required by Working Plan Officers in prescribing the yield of several species in mixed forest (Madras).*

I will summarise the work that has been done in the different provinces. In Bengal, linear plots were started in 1923, and so far 15 miles have been laid out in four main forest types. They have 5-year remeasurements and they measure every tree over 4" diameter for all species. The objective as defined in the paper was as follows :—

Objectives.—(*a*) Botanical survey, recognition of unknown species and distribution of all species.

(*b*) Authentically determined trees for seed and study.

(*c*) Some idea of diameter increment of all species, and

(*d*) Some idea of mortality and change of constitution of forests due to fire-protection.

In the U. P., linear plots one chain wide were started last year by Mr. Mobbs and his assistant Mr. Negi, 13 miles were laid out and it is proposed to lay out a further 20 miles during the coming cold weather. The general idea is to try to get 5—8 miles of lines in each important working circle in two or three divisions and it will take two or three years to lay them out. Remeasurements every five years, and if possible before and after main fellings as well. The primary objective is to ascertain, for one species only (*sal*), growing in a mixed forest of many species, an average value for a working circle of diameter increment and wastage ; that is, what proportion of the stems in any diameter class will pass up to the next diameter class within a certain period of years. This is the information required by working plan officers to apply selection yield controls. The objective is thus quite different to the objective in Bengal.

In Madras, linear plots (some two chains wide and some one chain wide) were started 3 years ago and 27 miles have been laid out in three different types of forests, evergreen rain forests, mixed deciduous forests with teak, and dry deciduous forests with Red sanders (*Pterocarpus santalinus*). Their objective has been defined by Mr. Laurie as follows :—

> " The purpose of these inevstigations is to acquire reliable data regarding the girth (or diameter) increment of trees in irregular crops which can be applied to working plan enumerations for making accurate calculations of the yield."

The objective in Madras approaches that of the United Provinces rather than that of Bengal but is complicated by the desire to collect data for 3 or 4 different species in each type of forests.

The second point of the report reads as follows :—

(2) *That there must be a clear definition of the objective before any such research is started. Only then can the scope and methods be decided, which must assure that the objectives are attained.*

In an intricate problem such as we are considering, we believe it will be useless to start statistical research and a few years later ask ourselves what we should do with the data obtained. I believe that Bengal found some difficulty, after collecting data, in knowing exactly what was the best thing to do with them. This point therefore obviously does not require any elaboration.

The third point of the committee's report reads :—

(3) *That statistical research is at present chiefly required in mixed forests where only a few species (out of many) are exploitable. Yield tables for such forests are impossible at present.*

The fact that papers received from the three different provinces who have started this work show that they all deal with mixed forests of many species clearly indicate that it is in these types of forests that statistical research is chiefly required, so we can limit our subject to statistical work in mixed irregular forest. Troup when he started his investigations years ago on regular crops, and those of us who followed in his footsteps research in regular crops, had a very clear objective, namely, the preparation of yield tables. I think that with these irregular mixed crops that objective has to be completely ignored. I believe I am right in saying that nowhere in the world has any yield table as yet been published for any irregular crops even of a single species, that is to say pure forest.

[*Mr. Champion.*—There are yield tables of sorts produced for irregular unevenaged forests in the United States and in Switzerland, but I do not consider them suitable for our conditions.]

This fact, that for forests of this type yield tables can be definitely excluded at present, makes it all the more necessary that the objective of every research project that is undertaken should be clearly defined before it is started.

The fourth point of the report of the committee reads :—

(4) *That long linear plots 1 or 2 chains broad and several miles long in each Working Circle or forest type appear to be the best form for such research, and the method of successive plot enumerations, preferably at 5 year intervals and if possible immediately before and after main fellings appears the only feasible method of collecting data, either for botanical or Working Plan purposes.*

Here again that fact that in all three provinces the type of long linear plots has been adopted as the only feasible method clearly indicates in the opinion of the officers of those provinces that that type of plot is the best. That is why the committee have recommended more or less standardising that type of plot. I should like to pay my tribute to Mr. Shebbeare and Mr. Homfray and the other officers in Bengal who took the lead in laying out these plots in Bengal many years before it was thought of elsewhere. Mr. Champion suggested in his note that these long linear plots should be supplemented by rectangular plots chosen as typical of these forests in order to obtain some idea of the normal growing stock. The committee considered this carefully and concluded that in mixed forests there is no hope of obtaining any idea of the normal growing stock for one species out of many (see p. 218, lower half, and p. 219).

The fifth point of the committee's report reads :—

(5) " *That every stem (over a minimum diameter) of those species for which data are required should be measured and recorded by diameter or girth classes, and not only selected stems.*"

It appears necessary to guarantee that the best stems only are not selected for measurement. This is the criticism that was made, I believe, in Madras when their lines were laid out. By taking every stem over a minimum size we are helping to obtain the true average of the whole area.

The sixth point of the committee's report is as follows :—

(6) " *That where Working Plan yield calculations are to depend on statistical research, the simplest possible objectives should be adopted to start with. It is for example useless for the Working Plan branch to ask for the normal total growing stock of one species in a mixed forest, but it is reasonable to ask for the normal distribution of diameter classes to sustain the selection yield.*"

Referring for a moment to Mr. Laurie's definition which I will repeat— " The purpose of these investigations is to acquire reliable data which can be applied by working plans officers for making accurate calculations of the yield "—this is a very good definition, but the scope and method of the statistical research will depend on how the yield is prescribed in the Working Plans. In mixed deciduous forests for example, will the working plan prescribe a separate yield for each species or a combined yield for all together ? Again, will the yield be a total volume yield for all classes together or will the objects of management be met by prescribing a yield of selection size trees only, as we propose to do in the United Provinces ? The answer to each of these different possibilities would require to a certain extent different details of statistical research. These are the first questions to be answered, and it is therefore useless to decide on a method of prescribing the yield to which statistical research cannot in our present state of knowledge give an answer. For the Hill *sal* forests in the United Provinces we have adopted the simplest possible objective, namely, yield control of one species only, and from our practical experience up-to-date we find that even that objective is as much as we can manage. Your Committee were very definitely of opinion that working plan yield calculations must be made simple wherever they are to depend on statistical research.

The seventh point of committee's report is as follows :—

(7) " *That sub-division into quality classes, crown classes, canopy classes, etc., should where feasible be rigidly confined to the minimum required to attain the objective, and all unnecessary elaborations excluded. In some types of forest no such sub-division is possible, e.g., quality classes in wet evergreen forest. Over elaboration tends to make both the research itself and the application of results to Working Plans impracticable.*"

Mr. Laurie's note brings out very clearly the danger of excessive complications. He shows how a working plan officer might have to divide enumerations into 240 classes for each species ! During the last two years, working plan officers working under me in the United Provinces have enumerated about a quarter of a million acres of hill *sal* forests in our standard classes and we tried enumerating also in two very simple quality classes, over 70′ height and under 70′ height, and we found in practice that even that very elementary complication was impossible. The qualities were so muddled up on the ground that they merged into one another and when the large scale enumeration attempted to separate them it was found it could not be done. So that any idea of trying to enumerate in quality classes, crown classes, canopy classes, and so on, is quite impossible. And moreover, for the simple objective that we are satisfied with, I believe this elaboration is unnecessary. If you are satisfied with the selection yield control, you can ignore canopy classes and even to a great extent quality classes, because we want statistical research to give us an average answer for a whole working circle for perhaps a lakh of acres or more.

But to justify the assumption that we have a fair average we must have an adequate length of line for each area over which the results of research are to be applied. It is no good taking only a few chains or even a mile.

There is a story of a Divisional Forest Officer, a very meticulous fellow, who prided himself on extreme accuracy in his work and on one occasion worked out his requirements for barbed wire for his plantation to three places of decimals. Having done this he then sent an indent to a Calcutta firm for his wire, also to three places of decimals, and the Calcutta firm, not being accustomed to this extraordinary accuracy (I think the figure was 4071.352-ft.) ignored the decimal point and sent him 4 million and seventy-one thousand odd feet ! I think in this problem of statistical research we must avoid the mentality of that Divisional Forest Officer and it is useless for us to think in terms of three decimal places. Whatever answer we may get even with the most careful work, must be a rough approximation.

The eighth point of the committee's report deals with :—

(8) "*That where some tree classification is considered advisable the following shall be adopted* :—

(a) *Freedom of crown—*(*i*) *Dominant,* (*ii*) *Dominated,* (*iii*) *Suppressed.*

(b) *Size of crown—*(*i*) *Large,* (*ii*) *Medium,* (*iii*) *Small.*"

Although we believe that a working plan officer will never require a tree classification on these lines, it is possible that statistical research itself might find such information useful in future, and if it can be collected without extra trouble there is a feeling that this should be done, and research officers should note down classification of trees they measure on these lines. The difficulty of applying even this simple classification to irregular forests is obvious and the best classification would only be rough but it does not take much trouble to note it down and it is better to do a little more, than to find later on that you want something and cannot get it.

The last point of the committee's report runs as follows :—

(9) "*That it is at present too early to try to standardise methods of analysis and application of results.*"

This point I think is perfectly obvious and really requires no explanation. You cannot analyse results if you have not got them nor can you apply them.

Summarising all this, the committee have made a recommendation.

"*The Committee, therefore, recommends that the Central Silviculturist be asked, in consultation with provincial research officers, to write an addition to the Statistical Code on the lines indicated above, and to include a section describing the technique so far developed in different provinces, with suggestions for methods of analysis and application of results in future. The committee further recommends that as the subject is of importance to most provinces, co-operative investigations should be undertaken by the Central Silviculturist and provincial research officers should keep in close touch.*"

By this co-operative investigation, I think we really mean not so much a tour such as was made in the case of *sal,* but keeping in touch through the Central Silviculturist who could help by disseminating information from one province to another. There would be more correspondence than touring.

At the commencement I said I hoped the conference would carry the matter of research in irregular crops a stage further than where the last conference left it. The committee have put in a good deal of hard work and hard thinking and if its report is endorsed by this conference I think we shall have definitely advanced not only beyond the stage at which it was left by the last conference but beyond any work carried on in other parts of the world on this type of work.

Mr. Shebbeare : I have only one point to make about the classification and the position of the crowns. I sent the record of a linear sample plot to Mr. Bor in Assam and he wrote back saying "I suppose this is a *sal* forest but the majority of the trees are *Meliosma*". This latter is simply an undergrowth species, and unless you do record the whereabouts of the crown, confusion will result.

Mr. Laurie : Mr. Smythies asked how we would prescribe the yield in our irregular crops of Madras. The position is rather different in the different we deal with, and when I defined the objects of the research, I had in mind our most important forests, namely the mixed deciduous. There we adopt a combined yield of all species irrespective of the relative value of individual trees. But it is quite conceivable that in teak bearing forests we might want a separate yield of teak on the lines on which the U. P. is doing it in their *sal* forests. In evergreen forests, it is doubtful if we would want to go into so much detail because upto the present no volume yield has been prescribed for them. It is entirely a silvicultural yield of only one or two trees per acre in accordance with the resolution of the last conference that we should not do any heavy fellings until regeneration problems in evergreens had been solved. In our open red sanders forests the only trees we are considering are red sanders, being the only valuable timber species. There again, some method comparable to the *sal* methods in the United Provinces will be adopted. The problem therefore is different in these three different areas and our method of research, of recording the data, and of analysing them would be different in each case.

Mr. Mobbs : The point which was raised concerning the question of widening the line to make a permanent sample plot. We issued instructions that wherever it was possible to widen a line to make a permanent sample plot typical of the average conditions, this should be noted down on the records. The net result was that no place was noted down, the reason being that it was absolutely impossible to determine a true average of the irregular crops. The irregular forest is not the same as the selection forest. You can perhaps find your ideal condition in selection forests, but an irregular forest consists of a series of even-aged groups. No one group of evenaged trees and no one quality class will give you a true average condition of the whole area. Consequently when we considered the question in the forest we did not consider it feasible to widen the lines in any place.

Mr. Champion : The report of the committee refers a good many things to the Central Silviculturist, as tends to happen in these reports and resolutions ! I was distinctly disappointed with the outcome of our discussions at the last conference. It should have led to a lot of research work but it led to almost nothing till the last two or three years when very definite progress has been made. The points in which the committee summarised its recommendations to the conference are for the most part acceptable to me as Central Silviculturist, but there are one or two which I think will have to be considered a little more fully and there are one or two points which have come up in debate on which I think possibly a little more should be said. Firstly, with reference to the linear plots, referring primarily to the linear plots as laid out by the United Provinces last cold weather—and I gather those in Madras too, although I have not seen the record—there arises the question of getting a representative sample. We have to be very careful not to confuse two matters here—extra careful because the particular difficulty I am going to mention has occurred constantly and is still always cropping up with reference to our research work in evenaged crops. When looking at a sample plot, I have very frequently heard the remark " But that sample plot is not in the least a sample of the division ". Now that is because the majority of forest officers who are not familiar with these things (though as a matter of fact the information on this point is gradually improving) think that because we use the word ' sample ', the reference is to the average of the forest or the division. As a result a good deal of propaganda, I think it is now fairly generally realised that the sample plot has no such object in view at all ; it is merely laid out to contribute growth data for a particular form of forest (age and type and quality) the ultimate object being to combine data from a wide range of plots to permit of subsequent analysis for standard conditions. We can then refer the average of the division to these standard conditions for the required growth data which are made available to the working plan officer. The position is exactly the same for this research on irregular crops which we now propose to undertake, with this difference that the analysis is a far more difficult proposition. It will have to be tackled on different lines to begin with. A point which was actually mentioned was that it is impossible to classify some of our types of forests by anything corresponding to quality class. I should imagine myself that time will show that that generalisation is not generally applicable. I think the criticism might be made that we know so little about these forests that generalisations are dangerous.

If these linear plots are to be used as a sample in all respects of the forest in which they are laid out, this should be a secondary objective, the primary being to provide data for analysis with reference to definable standard conditions. The United Provinces have actually laid out or intend to lay out such linear plots in practically all the working circles of all divisions concerned. I am sure that would not generally be possible in other provinces. Probably the counter to this would be that they are not needed in all divisions, for types being fairly uniform, they could be combined in the several divisions. As a research officer, I should have to say that this would be unacceptable without some sort of demonstration in the first place that it is permissible, and the project in the United Provinces will provide some sort of demonstration as to the possibility of such combination.

Now the committee has very wisely decided that standard methods of analysis is at present impossible. That of course I accept at once. We have hardly begun analysis. Here I was counting largely on the contribution of the United Provinces, but when I asked for a note on the subject I received the reply that they were not yet in a position to make any remarks on the figures collected during the course of a season's field work. I replied that I could not quite understand this because I understood that it had already been decided to lay out a considerably greater length next season and it appeared to me that the United Provinces would be very unlikely to undertake further work until they had scrutinised very carefully the results of the first season's work. Mr. Smythies has perhaps in the course of his remarks explained the reason. We are after several different kinds of information, and for certain working plan purposes rough average data which should be directly available from the lines will probably meet immediate requirements. I personally think we shall ultimately be forced to analyse these results just as we do for our standard even-aged plots, to see what we can get out of them. We may find that it is very little, but we shall certainly be able to derive growth rates for each class of tree under any given conditions. We also need a measure of the accuracy of the derived mean values in application to different areas, which may be done by working up the data in two or three different sections, comparing sections and seeing how closely they agree.

I now come to my suggestion which was turned down by the Committee, that the lines should be supplemented by some polygonal plots, which could be maintained more or less as sample plots. The reasons given by Mr. Mobbs are perfectly valid but I do not think they cover the whole position on this point. We all know perfectly well that our so-called irregular forests are largely patches of crops in which one broad age class tends to predominate. It is surprising really, if attention is given to the point, how very little of our forests, as we have them now, are in their orignial condition. Personally, every time I make a tour I decide that less and less is, that more and more has been cultivated or devastated at some time in the past. Our irregular forest is a totally different thing from the selection forests aimed at on the continent of Europe. The reason why I consider that even so we should have a few permanent plots in areas approximating true selection forest is that whatever statistical growth data we get out of the proposed investigation, the figures will have to fall somewhere between those of the ideal selection forest and the even-aged forest. Suitable patches can be found if looked for, I am sure. Thus on the Lachiwala road, Mr. Howard some years ago asked me. "Did you notice that piece of *Terminalia* forest ? It is as near to a selection forest as you could wish." That would possibly be the type I am referring to. I think it would not be too much trouble for the provincial research staff, when they come across a suitable area such as that, to lay it out as a plot—just as we always ask them when they find a good opportunity to lay out of a sample plot for a species for which there is an immediate demand for crop data. I would like the Conference if it will support me in this matter, to allow my recommendation on this matter to stand, that if areas are encountered in laying out the proposed linear plots in which the age classes are fairly evenly distributed such sample plots should be made to give us in time the extreme range in the growth statistics from those of purely even-aged crops.

Mr. Smythies : When we were discussing this in committee, the difficulty was not getting typical plots with different ages represented, but the difficulty of the extreme mixture of species.

Mr. Champion : Then may I qualify my recommendation by saying that it would only be applicable to relatively pure crops ? Just as in our regular sample plots, we are prepared to accept 90 per cent. purity.

Mr. Mobbs : We could easily have found selection patches of pure *sal*, but our great bother was to get them for other species and so we actually did not select them.

Mr. Champion : The object should be clear, namely to have representative samples to give some idea of the range of conditions.

As regards the proposals for field work, I think I can agree with them all without comment.

The tree classification has been tried out by several of us and I do not think we could have anything simpler than we have proposed. Mr. Mobbs pointed out the need of having some sort of classification and I should like to stress this. It is impossible to say just how the information will be used, but it is a fact that I have frequently made use of the corresponding records in our sample plot files. In my opinion the position we are now discussing is far too vague for anything more to go into the *Statistical Code* than a description of how linear plots might be laid out, and I think these further points with regard to suggestions for analyses and application of results should not yet find a place in the Code. If we do not put it in the Code it is obvious the committee consider it should be placed on record elsewhere and I presume this is another of those things on which we require a report.

Mr. Smythies : By an addition to the Code, we meant really a separate little note ; we want the information disseminated.

Mr. Mobbs : Mr. Champion has stressed the point of immediate statistical analysis. The committee stressed the point of a simple definite and well defined objective. Now in the U. P. we have a very simple and well defined objective, and this objective does not call for any analysis whatsoever until the first remeasurements take place and one reason why we have not done any analysis so far is because we are not quite sure what sort of analysis is wanted immediately. We know what sort of analysis we are going to do for our own province in five years time but we are not quite sure what sort of analysis Mr. Champion wants immediately

Mr. Champion : The reason why I think an analytical study of the data so far collected is necessary is that it is likely to have a bearing on further work. We have got data chain by chain. We know they cover all sorts of species mixtures and a big range of quality class and the trees have very varying amounts of growing space. It is on this sort of points, to see what is possible, that analysis is required to see whether we should modify or supplement our further work in any way.

Then there is the question of the remeasurements of these lines. As it stands in the committee's report the period of plot enumeration is preferably at 5 year intervals and if possible immediately before and after the main fellings. I personally think that is not the best way of going about it. When the original draft was drawn up and I was given an opportunity of commenting on it, I asked particularly that if it was possible, the plot should be laid out in coupes about to be marked for felling in the coming season. Actually I understand it was not possible but we do require these measurements to cover the period from one selection felling to the next. It is mainly at the fellings that the changes in which we are interested, take place. I want the measurements made shortly before a felling and checked after it. If it can be done after the marking to ensure that this is done in the plot exactly as it is done outside, so much the better. I want the second full measurements taken after the second selection marking has been done.

Mr. Mobbs : The reason why the committee said we should measure if possible before and after these fellings was that in one year we might have thirty or forty plots to measure, and in another year we may have none. Obviously with a limited staff it is not possible suddenly to cope with a great rush of work one year and sit idle next year.

Mr. Champion : I believe the United Provinces has a five year programme of statistical work for regular sample plots. Actually the arrangement between the United Provinces this year was that we did their regular plot work in order to free their party to do the work in irregular crops. We have got the essential data from our regular plots and there is now no objection to putting off regular sample plot work for a year ; I should strongly recommend that if a large number of lines were coming in the coupes of one particular area, you should leave your regular sample plot work and put your party on to this problem. We have agreed to reduce the evenaged crop work as much as possible, and if we are going to take up this irregular crop problem, we must do it properly.

Then as to the question of part of the line falling in one coupe and part in the next ; that of course is bound to happen. It is obviously a difficulty but I think it could probably be met exactly as has been suggested with interim measurements for our regular sample plots ; the same precision will not be required if you have got full details at the first measurements two or three years before. The obvious errors in the less scientific interim remeasurements would be apparent in the record and we should be prepared if it were necessary to meet the actual practical conditions of the case and send a trustworthy subordinate to do the work. Would that meet requirements ?

Mr. Smythies : You emphasise that remeasurement before and after felling was more important than every five years. I do not think we could do both.

Mr. Champion : I propose the 5 year remeasurement be waived.

ITEM 12.

Species for which crop yield tables are desirable.

The Central Silviculturist in reporting progress made on the 1929 resolution asked if the Conference considered yield tables should be prepared for teak plantations. After opinions had been expressed by representatives of the teak growing provinces, the following resolution was proposed by Mr. H. C. WATTS (Central Provinces), and seconded by Mr. KAKAZAI (Statistical Assistant to Central Silviculturist) and passed by the Conference.

RESOLUTION ON ITEM 12.

RESOLVED that—

In view of the fact that sufficient data are available, the compilation of yield tables for teak plantations would serve a useful purpose and should be undertaken by the Central Silviculturist.

Report of the Silviculturist, Forest Research Institute, on action taken on the resolution passed by the 1929 Conference.

The resolution listed 19 species for which sample plots should be laid out with a view to ultimate compilation of yield tables. There are now the following numbers of plots :—

Species.	Number of permanent sample plots.		Maximum age of plantations.	Temporary plots.	Number of measurements.	Remarks.
	Natural Forests.	Plantations.	Years.			
Acacia catechu	7	2	8	2	19	
Alnus nepalensis	1	7	10	2	13	
Eugenia jambolana	7	1	5	2	14	
Quercus incana (Coppice) ..	33	1	46	..	101	
Terminalia tomentosa ..	24	8	10	5	63	
T. myriocarpa	..	12	11	..	15	
Casuarina equisetifolia	..	9	17	9	24	
Cryptomeria japonica ..	..	12	37	7	22	
Dalbergia latifolia	..	1	13	..	2	
Gmelina arborea	..	29	15	..	48	
Michelia champaca	..	6	11	..	9	
M. excelsa	..	3	40	..	6	
Acacia arabica	..	..	..	4	..	Also numerous Temporary plots measured in Sind.
Dipterocarpus pilosus ..	1	..	..	..	1	
D. turbinatus	6	2	8	..	14	
Lagerstroemia flos-reginae ..	2	9	15	..	16	
Populus euphratica	9	..	..	..	9	
Cinnamomum cecidodaphne ..	..	3	13	..	5	

A provisional yield table has been published for *Quercus incana.* Six species were listed for which single tree growth statistics were needed : of these, *Trewia nudiflora* in the United Provinces was dealt in an *Ind. For. Rec.* in 1933 and some stem analyses have been made in Bengal for *Gmelina.* The other species were *Adina cordifolia, Dalbergia latifolia, Ougeinia dalbergioides,* and *Pterocarpus marsupium.*

Item 12.]

Report of Debate.

The President.—Is it the general view of Burma that you would like teak yield tables prepared or not ?

Mr. Villar.—This is certainly a matter of considerable importance to Burma and I think from the Burma point of view these tables are necessary..

The President.—If it is the general desire that compilation should take place, the Central Silviculturist will compile them.

Mr. Laurie.—In Madras, it is felt that the yield tables are not required for some years to come and there is no real object in revising the Nilambur tables at present.

Mr. Garland.—I think the situation in Bombay is very much the same that we have practically no plantations except quite young ones.

Mr. Champion.—The yield tables serve two purposes, one of which is not really affected very fundamentally by the remarks just made by Messrs. Garland and Laurie, the calculation of rotation and fixing of conversion period. We need a yield table in India as much as anything for considering our policy in the matter of what we can expect from a teak plantation if it develops as we think it will. The other purpose is the prediction of the yields from existing crops in the near future. It is a comparatively easy matter to determine what the locality quality is from the existing irregular natural forest. The yield table will give a volume in figures for teak plantation in that particular quality and you then have a figure to go on which is admittedly a mere estimate but is something much better than what we usually have to manage with—which is a mere guess. I think personally this is a matter that has come up a great deal of late and we are going to discuss it in regard to regeneration of the mixed deciduous forests. In most cases there is a tendency to turn them into teak plantations and we need some such prediction before we can examine the financial side.

Mr. Pillai (*Travancore*).—So far as we are concerned we have not seriously thought of utilising these tables. At present, so far as we are concerned, we are mainly felling trees growing on private lands. Up to now plantations have not been at all expensive and it will probably be another 20 years or more before they will be utilised.

Mr. Osmaston.—In Bihar and Orissa we are making plantations on a far more ambitious scale than hitherto but until we know what we can expect, it will be premature to express an opinion.

The President.—I think it is the general view of the meeting here that there is no harm in making these tables, and as the information is available I think we might agree that the Forest Research Institute should bring out a table for teak. It cannot do any harm and it may be of some use.

Mr. Champion.—It will take about three months if I put my statistical staff on to it.

The President.—I think we might agree to undertake it between now and the next conference. Is anybody interested in *Casuarina* ?

Mr. Laurie.—Madras is collecting information regarding *Casuarina* from felling data which will give the outturn of *Casuarina* in different qualities.

Mr. Garland.—Bombay is interested in *Casuarina* but we have only few figures.

Mr. Champion.—As regards *Casuarina,* it is a far easier proposition than we ordinarily get. Our *Casuarina* is practically all planted and of known age. A yield table can be made with a minimum of time and trouble.

The President.—I think we might make a note that statistics for *Casuarina* should be kept.

ITEM 13.

Species for which volume tables are required.

No notes were received on this subject. The Silviculturist, Forest Research Institute, reported progress made on the 1929 resolution and a brief discussion ensued. No resolution was put before the Conference.

Report of Silviculturist, Forest Research Institute, on the action taken on resolution passed by the 1929 Conference.

Co-operation was recommended for the collection of the necessary data for 28 important species excluding the Burma list. Out of these, tables have been published for *Quercus incana* by the United Provinces (1931) and for *Bombax malabaricum* and *Trewia nudiflora* by the Forest Research Institute (1933). Assam Working Plans have included provisional figures for *Terminalia myriocarpa, Lagerstroemia flos-reginae,* and *Dipterocarpus macrocarpus.* Volume tables for species not included in the list in the resolution have been prepared as follows :—

Holoptelea integrifolia.—F. R. I. in U. P., *Ind. For. Rec.,* 1933.

Pterocarpus santalinus.—Madras, 1934, not published.

Mesua ferrea.— } Assam working plans for Sadiya and
Altingia excelsa.— } Lakhimpur divisions.

Report of Debate.

Mr. Laurie.—I discussed this question with a working plan officer just before coming to the conference and it was decided that volume tables are not ordinarily required by District Forest Officers. We collected a number of opinions from different forest officers and they all decided that volume tables were of very little use to them. The only application of volume tables in Madras is by working plan officers and they only use them within a restricted range of quality in their area. It was decided that the necessary volume tables could probably be prepared by the officers themselves in the course of their working plan work. So we found we did not want any volume tables prepared.

Mr. Garland.—The only two species which we are interested at all in Bombay would be *babul* and *Bombax.* We have a certain amount of data.

Mr. Watts.—The same species are the chief in the Central Provinces also.

Mr. Champion.—We have co-operated with one of the D. F. O.'s in Sind for *Acacia arabica* but nothing has been published yet. I would suggest that we leave the list as it is as suggestions to the provincial research officers that when their staff have nothing more important to do, they can always usefully turn them on to the collection of statistics of this particular kind. Actually the work will usually be done by the working plan officers.

ITEM 14.

Methods of research on thinning.

The only paper contributed was by the Central Silviculturist, which was circulated before the Conference, but short notes were received from several provinces. The subject was introduced by Mr. Howard (United Provinces) who reviewed Mr. Champion's paper in its application to working plan practice. Messrs. Trevor, Laurie and Chaturvedi also took part in the ensuing debate, and Mr. Seaman, Officer in Charge, Timber Testing Section, spoke on the subject of the relation between the width of annual rings and the strength and other properties of timber.

The following resolution was proposed by Mr. Howard, seconded by Mr. Harnam Singh (Kashmir) and passed by the Conference.

RESOLUTION ON ITEM 14.

Resolved that—

1. *The recommendation of the last conference be confirmed that we should continue to miss no opportunity of laying out as nearly comparable sets of plots as we can find, as the most economical method of finding out what we need to know in this field. Even where initial comparability falls short of the standard aimed at, every additional set of plots provides valuable data for comparison with other sets.*

2. *More crown thinning plots are needed especially for* sal *and deodar.*

3. *Heck's and Gehrahardt's methods of thinning should be added to our standard list to be tried out where an opportunity occurs. Both methods would be applicable to* sal *and deodar, whilst Heck's should be valuable for these species as well as for teak where there is no sale for small sized trees.*

4. *Diameter distribution tests should be added to the routine testing of comparative plots.*

5. *Hart's, Geerling's and Grochowski's suggestions should be tried out by the Central Silviculturist in the Institute plantations or in suitable crops elsewhere.*

6. *A standard classification of thinnings in young plantation crops is required on the lines of the classification of thinnings in more mature crops which have developed more definite crown classes.*

Report of the Silviculturist, Forest Research Institute, on action taken on the resolution passed by the 1929 Conference.

The resolution included 11 recommendations for procedure and the action taken is as follows :—

(1) and (2). The tree classification proposed has been adopted and was published both as an *Indian Forest Record* and in the *Statistical Code.* Dissatisfaction has been expressed with it in its application to young crops, especially plantations.

Item

(3) A limited number of contiguous sets of comparative plots have been laid out, bringing the totals in 1934 to the following numbers (possibly incomplete) :—

Species.	PROVINCE.				Total.
	BENGAL.	PUNJAB.	KASHMIR.	BURMA.	
	Number of sets of plots.	Number of sets of plots.	Number of sets of plots.	Number of sets of plots.	
Tectona grandis	1	..	..	12	13
Shorea robusta	8	..	..	..	8
Dalbergia sissoo	..	4	..	..	4
Cedrus deodara	..	..	1	..	1
Pinus excelsa	..	..	6	..	6
Gmelina arborea	1	..	..	..	1
Terminalia myriocarpa	1	..	..	..	1
Cryptomeria japonica	1	..	..	..	1
Xylia dolabriformis	..	..	..	1	1

Bihar and Orissa has a set of 12 thinning plots for *Cleistanthus* which are being constituted into sample plots.

Madras has selected a site for a replicated set of plots with 4 grades of thinning for *Tectona grandis* and others for age of first thinning and periodicity of thinning.

The Forest Research Institute has 2 replicated sets of very small plots in *Pinus longifolia.*

Yield tables have been published by the Forest Research Institute for *Cedrus deodara* for 4 thinning grades.

Many other single and grouped " thinning " plots exist notably for *Cedrus deodara,* the comparability of which has not been specifically claimed.

(4) The method of checking the marking made on the basis of standard tree classes and thinning grade, against the yield table number of stems for the crop diameter, has been described in the *Statistical Code* (page 225). It has been followed by Forest Research Institute parties but apparently not by provinces.

(5) Check of number of stems against crop diameter does not appear to have been applied as a routine step in sample plot measurement work.

(6) A considerable amount of work has been done on the measurement of standing sample trees by the Central Silviculturist and the results were published in 1933 as *Forest Bulletin 82.* Forest Research Institute field parties have successfully utilised the method as part of the routine procedure on large sample trees not available for felling, in both hills and plains. Photographic methods are still under examination.

(7) The detailed study of crown measurement data has not yet been taken up.

(8) Some work has been done at the Research Institute on form quotients but the subject has still to be examined in detail.

(9) The recommendation to provinces to make a special effort to start the collection of data for increment with extra heavy thinning has hardly been acted on except in Bengal plantations.

(10) A comparative study of frequency of thinnings has nowhere been taken up yet. It was discussed in the *Statistical Code* (page 222) and a replicated series of small plots laid out in 1934 in young *Pinus longifolia* plantations at the Forest Research Institute. Madras intends to lay out plots in young teak in 1934-35.

(11) Differentiation of a lower storey in standard sample plots is prescribed in the *Statistical Code* (pages 118-119) and is being done in practice.

H. G. Champion.

PAPER (1).

By H. G. CHAMPION, *Silviculturist, Forest Research Institute.*

The following is a survey of additional information on the subject of thinning research which has been collected from all available sources since the last Conference :—

A.—Foreign Work.

Since the 1929 Conference there have appeared two important publications on the general subject of thinning :—

A. Dengler.—" Waldbau auf ökologischer Grundlage ", 1930 :—A masterly survey of the present position with regard to thinning methods and thinning research (pages 452-465).

C. R. Heck.—" Handbuch der freien Durchforstung ", 1931 :—An exposition of a method dependent on the selection and special tending of evenly spaced first class stems.

The last-mentioned has called forth a great deal of discussion but there is fairly general agreement that whereas the proposals are far from new, the central idea is one that is finding widely increasing favour. A review in English which reflects this general opinion is GUILLEBAUD's in *Forestry* (1931, pages 75-78).

In addition to this, the views propounded by E. GEHRHARDT under the title " *Schnellwuchsbetrieb* " have also been freely discussed and come in for a great deal of criticism. They also primarily turn on selecting and favouring the stems of the future, and the only special point which need be referred to here is the attention given to relative crown length, an optimum being determined from direct observations and the actual thinning aiming at getting and keeping this optimum. It may be noted that the heavy fellings involved are only possible in good quality sites and necessitate pruning the favoured stems (*cf.* CHAMPION, *Indian Forester*, 1933, pages 372-79).

Further, the results obtained in Austria with heavy thinnings in beech and published by H. SCHMIED (*Loc. cit.* and Mitt. Forstl. Mariabrunn, 1931) call for mention, as also the publication of analyses of results from the important series of thinning plots in Bavaria (L. FABRICIUS for Kulmbach, etc.), in Saxony (J. BUSSE at Markersbach and Reudnitz), and in Prussia (E. WIEDEMANN). On the whole, they confirm the view that the variation in total production is not influenced to any important degree by the thinning intensity, but that the increment can be concentrated on a smaller number of selected good stems by the heavier grades particularly on good sites.

W. Schädelin has put forward (Schw. Ztsch. f. Fw.) a new tree classification which claims to be simpler and better based than the older ones, with four canopy classes, our D 1, D 2, *d* and *s* followed by 3 bole qualities, good, medium and bad, and finally by 3 crown classes likewise good, medium and bad. He has not however developed this into a thinning scale and only presses for its adoption for practice not research. As anticipated, HECK and others are very critical.

There have also been several published contributions on research methods which call for consideration :—

1. H. M. J. HART.—*Number of trees and thinning. A Preliminary investigation into the most desirable planting space and method of thinning for teak.*—Medd. No. 21 of the Dutch E. Indies F. R. I., 1928. The author sets out to devise an objective method for carrying out the thinning in his research sample plots, and beginning with the differentiation of canopy refers these to what we now call top height (he calls it " thinning height "), here actually the mean height of the 100 tallest trees per hectare (40 per acre), and shews that no appreciable error is introduced if the tree with biggest diameter is measured on every *ar.* The dividing line between dominating and dominated canopy is then taken to be ¾ this top height. Obviously for each species the most suitable proportion can be standardised, and measurement would only be necessary for borderline trees. He then assumes that the dominating trees stand in triangular spacement so that the average spacing will be $107.45/\sqrt{N}$ and the thinning degree is represented by the percentage relation between the average spacing and the thinning height. Beekman's teak yield tables correspond to a thinning degree rising from 21 at 5 years to 29 at 100 years, and research plots can be thinned largely objectively to any desired degree ; Hart was experimenting with 15 to 30. Obviously the method can only apply to different intensities of the same kind of thinning.

It has been tested on our yield tables for deodar and *sal* and found to be possible of application. The Deodar yield table corresponds to a Thinning Degree of 15—18 from 50 ft. or 50 years upwards but definitely higher figures earlier in the important thinning period. The *sal* tables fall between 21 and 25 throughout except for the higher ages of the lower qualities, which may well be due to defects in our sample plots for that range.

2. K. PHILIPP.—*The co-operative system of Forest Management, 1930* (cf. CHATURVEDI, *Indian Forester, 1932, pages 273-76*).—The writer introduces a rather unsatisfactory term *Wirtschafts-stufe* or *working stage* to express 10 per cent. ranges in the proportion of the intermediate yields to the total yield using special yield tables on a basis of height. Top height is measured and is found from the tables to correspond to a certain total production irrespective of age or quality : the percentage relation of the actual standing volume to this total production gives the working stage, which can then be adjusted to any desired standard. For research work again, this could only be used for variations of intensity, not kind, of thinning. The total production table is really only a convenient standard of reference and could be compiled from our existing yield tables.

3. M. LEEVI.—" *On thinning grades and their application* ", 1930.—This paper of 105 pages in Finnish with a German summary, among other matters discusses the distribution of the numbers of trees in a crop and their volume, between the several canopy classes, and suggests that comparisons on this basis would be useful in defining different thinning grades.

4. W. JEDLINSKI.—*On the use of tree diameter and height distribution curves to regulate various thinning methods.*—Proc. International Cong. For. Exp. Sta. Nancy, 1932, pages 276-98. This paper is illustrative of the development, particularly in the Baltic countries, of the use of the form of diameter and height distribution curves for the study of crop composition and its regulation. If these curves are not similar for proposed comparative plots, the plots are inacceptable. The form of the curves varies appreciably with the kind and intensity of thinning and might up to a point be used to regulate the latter, but the details have not been worked up.

5. BARRET AND RIGHTER.—*Experimental Thinnings, Journal of Forestry, 1929.*—These workers have made a mathematical study of the distribution of the diameter classes in standing crops with special reference to determining the comparability of plots to be used for comparative thinning studies. The probable error of the difference between the mean diameters should be more

than one-third of the difference for the difference not to be significant, so that the plots may be accepted as comparable.

The general proposition is acceptable and diameter being the simplest factor to work with, may be taken as indicative of the others. Applied to representative examples of our existing sets of plots, it would result in the rejection of not a few of them (*e.g.*, Kurseong *sal* plots 20, 21, 22). It seems questionable, however, whether this method can be used to demonstrate comparability as it only provides negative evidence, but if applied to plots of acceptably similar basal area, it should be useful.

6. E. WIEDEMANN.—*" On the thinning and increment plots of the Prussian F. R. I."*—Proc. Internat. Cong. For. Exp. Sta. Stockholm, 1929. Strictly comparable plots are virtually unobtainable and the only solution is an analysis of the results of a series of the best sets of plots, graphical analysis being preferred. Owing to difficulties in accurate measurement, diameter and basal area provide a better basis for comparison than height or volume.

7. J. GROCHOWSKI.—*Research Methods on the influence of thinning and increment fellings on the development and increment of trees and crops.*—Proc. Internat. Congress For. Exp. Sta. Stockholm, 1929, pages 243-47. This Polish worker considers that two types of sample plots are needed, one like those we have in India, in which we deal with crop averages and need many plots to even out unavoidable and often unrecognised differences, and the other, small plots very intensively studied. The conditions under which each tree or group exists, its form, and its reactions to its changing environment require to be studied with very exact measurements and by analysing out and comparing the behaviour of different types of trees under different conditions, the general laws should be derivable for testing on the less intensively studied plots and for practical application. The Congress recommended this procedure in Resolution I 5.

8. L. G. GEERLING.—*Standards of Comparability of thinning sample plots at the Netherland F. R. Sta.* Proc. Internat. Cong. For. Exp. Sta., Nancy, 1932, pages 262-64. This paper represents the most intensive testing so far proposed and is obviously only possible under favourable conditions.

The area contemplated for a comparative set of plots is sub-divided into 5 metre squares and the height of the best two trees in each measured. The mean height and its standard error is computed and every square on which the height differs from the mean by over 2 E is marked on a plan. The plots are then so laid out as not to include more than 5 per cent. of marked squares and the mean height and its error computed for each plot, and to be acceptable the difference between the means must not exceed three times the error. Earlier trials by VON VLOTEN using only a few lines of squares in the same way, had proved unsatisfactory.

B.—Work in India.

It is difficult to report just how many sets of comparative thinning plots exist as only recently has serious attention been given to ensuring the essential initial comparability. A summary has however been attempted on page 226 from which it is apparent that systematic attempts have really only been made for *sal* in Bengal, teak in Burma, and *sissoo* in the Punjab. Though many sample plots exist for other species, particularly the conifers, with the object of making a comparative study of the effect of varying thinning treatment, they are dependent on comparison of average values from a number of similarly treated plots and not on comparison between development in single plots.

The *Statistical Code* devoted Chapter XI to *Thinning Research* and has formed the basis of recent work, but it has not yet been tested out under the necessary range of conditions, and existing sets of plots have still mostly to be re-examined in light of its proposals.

For initial comparability, the International Standard of not more than 10 per cent. difference in basal area, 20 per cent. in number of stems per unit area, and 15 per cent. in height was adopted. It will be noted that diameter difference is not specified but is regulated through basal area and number of stems. The test is applied after the lightest thinning grade has been applied to all plots of a set (page 225).

Item 14.]

Representative sets of plots have been examined by these criteria with the following results :—

Shorea robutsta, S. P. 20—22, Kurseong division, Bengal.

Plot No.	Basal Area in Sq. ft.		Number of stems.		Height in feet		Remarks.
	Actual.	% of mean.	Actual.	% of mean.	Actual.	% of mean.	
20	47·9	94	2,609	91	20	102	Before any thinning.
21	50·7	99	3,174	111	19	96	
22	54·6	107	2,805	98	20	102	

Gmelina arborea, S. P. 13—16, Chittagong division, Bengal.

Plot No.	Basal area in sq. ft.		Number of stems.		Height in feet.		Remarks.
	Actual.	% of mean.	Actual.	% of mean.	Actual.	% of mean.	
13	58·7	88	675	93	38	99	Before thinnings.
14	70·6	106	791	109	38	99	
15	74·1	111	837	116	37	96	
16	63·1	95	T592	82	41	106	
Mean	66·6		724		38·5		

Tectona grandis, S. P. 29—32, Zigon division, in 1924.

Plot No.	Basal area. Sq. ft.		No. of stems.		Height in feet.		Remarks.
	Actual.	% of mean.	Actual.	% of mean.	Actual.	% of mean.	
Zigon 29 ..	36·6	91·9	1,124	103·1	26	99	After removal of miscellaneous spp. and badly suppressed teak but before thinning real main crop.
30 ..	44·2	111·0	1,088	99·8	26	99	
31 ..	39·5	99·2	1,071	98·3	27	102·8	
32 ..	39·0	98·0	1,077	98·8	26	99	
Mean	39·825		1,090		26·25		

The comparability test by the probable error of the difference of mean diameter applied to the same sets of plots gives the following results :—

Shorea robusta, S. P. 20—22 :—

SP 22—21 Difference in mean diameter .. .. 0·15 ± ·009 D/E = 16·7

SP 21—20 Do. .. .. 0·10 ± ·009 = 11·1

SP 22—20 Do. .. .. 0·05 ± ·010 = 5·0

The plots are not comparable.

***Gmelina arborea, S. P. 13—16* :—**

SP 16—15	**Difference in mean diameter**	**0·37 ± ·0338**	**D/E**	**= 10·9**
SP 16—14	**Do.**	**0·38 ± ·0362**		**= 10·5**
SP 16—13	**Do.**	**0·42 ± ·0362**		**= 11·6**
SP 15—14	**Do.**	**0·01 ± ·0303**		**= ·003**
SP 15—13	**Do.**	**0·05 ± ·0303**		**= 1·7**
SP 14—13	**Do.**	**0·04 ± ·0330**		**= 1·2**

Plot 16 is not comparable with the rest but the latter are comparable.

Tectona grandis—

SP 30—29	**Difference in mean diameter**	0·2 ± ·019	D/E	= 10·5
SP 30—31	Do.	0·1 ± ·021		= 4·8
SP 30—32	Do.	0·6 ± ·022		= 27·3
SP 31—29	Do.	0·1 ± ·018		= 5·6
SP 31—32	Do.	0·5 ± ·022		= 22·7
SP 29—32	Do.	0·4 ± ·020		= 20·0

In this set, despite the good comparability on the previous tests, no pair of plots is acceptable ; the figures reflect the marked difference in number of trees in the 4″ diameter class (6, 51, 52, and 28 respectively).

These random examples show that acceptably comparable plots are available in young plantation crops, but even in them it might be questioned whether their mode of origin may not even up the sites for early growth, inherent differences coming into play later on.

Difficulty has been experienced in applying our standard tree classification to young crops, or rather in carrying out the standard grades of thinnings based on the classification. It is found that if a C grade thinning is made strictly according to the rules in such crops, it bears little resemblance to the same operation done in an older pole crop and could not possibly be called a " heavy thinning ". It must be accepted that the published thinning scales are unsuitable for application to dense young crops and a different basis is needed [*vide* paragraph D (3) on page 233 of the *Code*]. For research work the chief need is for an acceptable standard of reference, which may be very arbitrarily determined if necessary. Our yield tables tend to miss out the early stages of growth, and the number of stems per acre curves are two steep for suitable extrapolation. It is suggested the *n*|*d* curve can be derived from a Spacement|*d* curve assumed to originate from the 6′ × 6′ spacement but applicable also to closer spacements and line sowings. In carrying out the thinning, the general principles of the standard scale can stand, but the classes to be removed under any grade will be extended to include such proportion of those prescribed for the next higher grade as is necessary to bring down the spacement to that determined by the numerical check for the relation between thinning grades. Spacement|*d* curves would be drawn for each thinning intensity to be studied. As usual the special requirements of research technique, and large scale practice must constantly be borne in mind.

The objective control of crown thinnings is difficult and is becoming more important particularly in young crops of shade or semi-shade bearers such as *sal* and deodar. Basal area seems the obvious basis to adopt. One intensity, say the lowest would be done according to silvicultural rules, and the others by removing a predetermined greater proportion, say 120 per cent. and 140 per cent. of the basal area found to be taken in the lowest intensity. Comparison with ordinary thinnings must be on results, and there is no need to attempt such co-ordination as say removing the same basal area in one of the ordinary and one of the crown thinning grades. In experiments on free thinning concentrated on favouring selected dominants, the number of these per acre would provide a suitable guide, but the number will obviously decrease with increasing age or diameter. This difficulty might be met in any given set of plots by adopting a standard number for one of the set, say 240 trees to begin with and different proportions, more or less, for other intensities. As an alternative, different basal areas might be taken keeping the same number of

The latest method of thinning young *sal* taungya plantations in Bengal is tending to approximate to free thinning ; experience has shown that although dominants do declare themselves without thinning, they are badly distributed and the aim is now so to thin as to ensure even spacing of selected good stems.

Conclusions :—

1. The recommendation of the last conference is confirmed that we should continue to miss no opportunity of laying out as nearly comparable sets of plots as we can find, as the most economical method of finding out what we need to know in this field. Even where initial comparability falls short of the standard aimed at, every additional set of plots provide valuable data for comparison with other sets.

2. More crown thinning plots are needed especially for *sal* and deodar.

3. Heck's and Gehrhardt's methods of thinning should be added to our standard list to be tried out where an opportunity occurs. Both methods would be applicable to *sal* and deodar, whilst Heck's should be valuable for these species as well as teak, where there is no sale for small sized trees.

4. Diameter distribution tests should be added to the routine testing of comparative plots.

5. Hart, Geerling and Grochowski's suggestions should be tried out by the Central Silviculturist in the Institute plantations or in suitable crops elsewhere.

6. Our standard thinning classification should be supplemented to provide adequately for dense young crops ; the present classification only deals with crops after the crown classes have formed, and in very young crops they have not formed.

Notes.

(*i*) *Punjab.*—In the irrigated plantations in the plains the crops are quite uniform over extensive stretches and there is no difficulty in laying out sets of plots with necessary replications with ¼ acre to one acre sub-plots. The only trouble comes in with heavy mortality in younger crops through white ants in the interval between the measurements which may sometimes efface the effect of thinnings in the two contiguous grades.

In the coniferous forests, except in plantations, it is invariably difficult to find uniform crops over sufficient areas to lay out sets of plots. Generally it has been found possible only to lay out 2 plots (area about ½ acre each) at a place comparing two grades of thinnings. If the minimum size for a plot is reduced to ¼ acre then it might be possible to have 2 replications for two grades of thinnings at a place.

Another difficulty experienced in hill forests is about the plot surrounds and suitable sample trees for main crop. Very often the condition of stocking does not permit for provision of adequate surround and there is a dearth of suitable sample trees particularly for higher diameter classes. To ensure proper comparison it seems necessary to resort to measurement of standing sample trees within the plots.—*Pratab Singh.*

(*ii*) *Bengal.*—The following sets of thinning-plots have been laid out, all in young plantations :—*Shorea robusta* (6 sets), *Cryptomeria japonica* (1 set), *Terminalia myriocarpa* (1 set), *Tectona grandis* (1 set), and *Gmelina arborea* (1 set).

Plots of a set are contiguous with a dividing strip of varying width. So far only one thinning has been done. A set—with the exception of teak and *Gmelina*—consists of 3 plots, B/C grade, C/D grade, unthinned control. The thinned plots all received their first thinning in the same year. The unthinned plots are required since in many cases early thinnings are unsaleable and it is possible that natural crown differentiation will take place to such an extent that the cost of the early thinnings will not be justified. Bengal experience with *sal* and *Terminalia myriocarpa,* has shown that the dominants do declare themselves as early as the 4th to 5th year, but they are unsatisfactorily spaced and so render later thinnings difficult to carry out satisfactorily. Accordingly, the first thinning is now primarily viewed at ensuring even spacing of dominants. The question of early thinnings is also bound up with climber control ; present indications are that this will be cheaper in thinned crops than in the unthinned (this refers to line sowings).

Initial comparability has on the whole been obtained, but suitable sites for larger sets could not be found without difficulty, even with ¼ acre plots.

Tree classification according to the *Statistical Code* in young *sal* plantations is impossible, and therefore thinnings to the standard grades cannot be carried out, so some other method is required to ensure the elimination of the personal factor.

With teak, the set consists of four plots thinned by number of stems per acre for the known age as compared with Blanford's figures in *Burma Forest Bulletin,* No. 9, Silvicultural Series, No. 8, published in 1923, one plot being thinned to Blanford's number, one more heavily and one less heavily, and an unthinned control. A similar method was adopted for *Gmelina* having reference to older plots which appeared satisfactorily thinned.—*C. K. Homfray, Silviculturist.*

Report of Debate.

Mr. Howard.—When Mr. Champion wrote and asked me to open the debate on the item entitled " Methods of Research on Thinning ", I wrote back and pointed out that I had not been directly connected with any of this work for eight years, that it was extremely technical, and that I knew nothing about it. His reply was that that was why he had asked me to open the debate. I do not know quite what he meant by this, but I gather he meant that he did not want me to say anything, but he really wanted the professionals to get up afterwards and wrangle. And the best thing I can do is more or less to leave them to do that. I imagine that many of you are in the same position as myself, that is to say, that although you are extremely interested in all the different types of thinnings and the results, you are not familiar enough with the more technical side of the actual methods of such research really to do more than listen.

Mr. Champion has reviewed recent work which has been done first of all in parts of the world other than India. He has summarised the literature of the various people who have written on this subject in the last few years, and it seems to me that the conclusion which he would draw from this recent work is that of the general tendency of research was first of all towards what he calls " free thinning ", by which I understand that he means selecting a definite limited number of stems to the acre and subordinating all treatment in the area to their encouragement. In other words, rather like heavy crown thinning systematised.

The other point which he seems to bring out is that an important characteristic in European work at the moment is the idea, while selecting and favouring these " stems of the future ", of paying greater attention to the relative length of the crown. Apparently an optimum length of crown is determined and then by thinning an attempt is made to keep the crown at that optimum.

Mr. Champion says in his note that the necessary heavy thinning can only be practised on really good sites. I should like him to tell you is how to determine that optimum ?

The rest of the review of work outside India, I think, is too technical for me to refer to now. When we come to the research work done in India, although Mr. Champion has been very polite in the way he has written it, I am afraid what he wanted to say is that all we have done in the past is of no use. And it seems to me that what he is really urging this conference to do is to get down to it and really start some comparative research on thinning with plots laid down in such a way that the results we get from them give us a true answer. I gather that is really his objection to all the plots we have laid out in the past.

Mr. Champion said that what he wanted me to speak on the bearing of thinning on working plans. It is rather a difficult question to answer because conditions are so very variable. If he works out that the best system of thinning is something which means my going and thinning among trees two inches in diameter, usually nothing on earth will induce me to do it because I could not afford to. It is commonly far too expensive to be worth doing. But if he means a more general proposition to apply in places where I can afford it, should I be prepared to do it, then the answer is equally emphatic of course,—that is what I am there for. I cannot see that any research results which he obtains and proves are likely to be in any way difficult to introduce into working plans. I cannot imagine that he is likely to find that we cannot make use of it and the real point about it is this that if he can find any method by which he can produce trees with relatively clean boles within a relatively shorter time, he will probably have done far more good to forest management than a great many things we have done for many years. If we can have a shorter rotation for our timber, it will quite obviously make an amazing difference to us.

Years ago it was more or less proved by a friend of many of us, Dr. Flury, that whatever you do in thinning, you make no appreciable difference to the amount of stuff you produce out of the ground, provided that you do not thin so heavily that you leave a crop less than the ground could support. But of course remember he said " total produce " and that is not what we are interested in. We want material we can sell and there is no doubt whatever that different methods of thinning, although they cannot alter the total amount, can alter the distribution. That is to say they can put the increment on a few trees instead of on many trees. In other words you can enable a selected number of trees to get most of the nutriment from the soil, which in only another way of saying that you can get a larger number of large trees.

Mr. Seaman.—I believe that Mr. Trotter has already told you about the general conclusions we have reached concerning rate of growth. There is a definite correlation between rate of growth and strength but I am afraid that rather wrong impressions have got abroad. I presume it is our own fault. We presumed that everybody would accept wood as a variable material and realize that we could not lay down a hard and fast rule to which every piece would conform. I observed this wrong impression about two years ago when a certain forest officer said, " you claim that the rapid grown wood is the stronger, but here is one rapid grown and one slow grown piece and the rapid grown is the weaker ". The fact is that it is certainly possible to find such exceptions, and all that we can give is a general average result. You cannot expect anything else, and what we really meant to imply in our publications,—and I presume we should have said so more definitely—is that with broadleaved trees of a ring-porus character the moderately rapidly grown wood is *on the average* distinctly stronger than that which grows more slowly. There are exceptions to every rule and in addition, strength increase with rate of growth is not without limit. You will sometimes find extremely rapid grown material which is very weak. If the rapid grown material is accompanied by considerable weight, it can then be expected to be strong with still more confidence but again the weight can be due to infilteration products. We have had a series of 200 tests from Rangoon which were sorted into wide-ring light teak, wide-ring heavy teak, and normal teak. The result was exactly what one would have expected. Taken on the average the normal teak, (which runs from 4 to 15 rings per inch), was the best of the three. The heavy wide-ringed teak stood second. The average for this lot was lowered by the fact that some of the samples that were sent were found to be composed of rather thin-walled elements with a very large amount of infilteration material of a gummy sort. The wide-ringed light material stood third on the list, being the weakest of the three. This, however, was very wide-ringed stuff. It had gone beyond the optimum limit, and it was obviously light owing to that, but even in this material there were individual specimens which were quite strong. Consequently all one can say is this :—that, on the average, a better chance of obtaining good strong material with ring-porous dicotyledons if it is comparatively rapidly grown, but that if it has less than four rings per inch, that is if the growth ring is more than a quarter of an inch wide, it comes within the range when it should be regarded with suspicion. From 4—15 or 16 rings per inch you can expect your best quality material, but if the growth rate is much slower than 16—20 rings per inch in the ring porous woods the timber must again come under suspicion. But do not think please, that I am saying that every 20 ringed piece is weak. There are always exceptions, and an individual slow grown piece may be very strong.

Puri and Nilambur teak have been mentioned. The teak specimens we tested from South Puri was distinctly below the average in strength. The Nilambur teak results are not published, but speaking from memory I believe they are much closer to average teak results than the results obtained from South Puri.

One more point :—these conclusions can only be depended on if the material sent to us for testing is representative. If a plantation enthusiast set out to send us the very best trees, and we received a poor lot of trees from natural grown forests, the result would be obvious. We can only give you the results from the materials received here, and for that reason we always ask the sender to be careful to supply really representative samples.

Mr. Howard.—This information simplifies one of our problems considerably because so far as my province is concerned we are never likely to grow less than 4 rings to the inch or more than 15. I understand from the rapid growing provinces that growth is so rapid that they can reduce the 4 rings to 2 rings but our safety margin is well between the two.

Mr. Champion's sixth point is that our standard classification for thinning should be supplemented to provide for dense young crops. I do not propose to add that to my draft resolution for I am not keen on having the classification tampered with. It has taken a very long time to get the ordinary forest ranger to understand it. He has eventually learnt to understand it but the first time we attempt to tamper with it we shall have trouble.

Mr. Champion.—I think probably Mr. Howard would be prepared to leave my proposal in, if it was made clearer as to what was intended, but on the other hand I should not be at all disappointed if the conference decided to exclude it. I put it in because of the practical difficulty that people have found when they have tried to use the classification in very young crops.

We all agree in fact that it cannot be done, and therefore it is desirable to modify or extend Mr. Howard's classification to cover the case, for the fact remains that we have to do thinnings in these crops and it would be very useful and avoid misunderstanding if we could make any other provision for including them. It could be included also in our research work but it is very definitely at the moment a divisional problem and it would be a good thing if we could do something about it. The meaning could be made clear that we have no desire to tamper with the present classification.

There is no question about it that if my proposals are acted upon, there is more work for the Silviculturists. Their present thinning plots are inadequate and if we take up the work properly they must give us new ones. Now it seems to me that the working plans branches should be able to help us in this matter by helping us to narrow the scope of our investigation. Mr. Howard in the course of his address did that to a very great extent when he focussed attention primarily on the production of large timber in as short a time as is reasonably possible. He said he thought that Heck's methods should be given special attention and this likewise my opinion.

A point which has recently come up is that we must pay much more attention than we have in the past to the differentiation of heartwood. The Economist has called on me several times recently for information on this matter and it arises particularly when we propose to aim at getting big trees by more rapid growth. Actually our present procedure does not provide for the recording of sapwood and we are proposing to put an amendment to the *Code* for making sapwood measurements a routine matter. These methods of thinning which concentrate attention of favouring the best stems, evenly

Item 14.]

distributed over the area—a point very much stressed by the European authorities mentioned—concentrate attention again on tree form. We must have good shape and most of the workers on these particular lines have one after another come to the conclusion that it will pay them not only to favour thinning of these selected stems but even to undertake pruning. If I asked Mr. Howard to prune the inaccessible deodar forests he would laugh at me, but that does not remove the necessity of bearing in mind that thinnings giving a large crown space will result in a more branchy crown, and a shorter clear bole. There is a limit to which you can go without any serious deterioration but we do not know where that limit is. At present our standard methods do not adequately provide for recording bole quality, and it is difficult subject, but we must do something about it. When you have to find reliable sample trees in two plots differently thinned anybody who has tried it will know it is absolutely impossible ; therefore, I think our methods of research in these problems will involve extended use of standing sample trees and that is one of the main reason why we have taken this up despite a good deal of ridicule over our rather Heath-Robinson looking devices. These ladders were used on trees 140 ft. high in the U. P. hills without introducing any special difficulties particularly as regards timber measurements.

Another point Mr. Howard brought out which I would like to emphasise again is that territorial officers are always forgetting the relation of crop diameter to the diameters of the trees standing in the crop concerned. We have recently supplemented two of Mr. Howard's yield tables with the best estimates we can make at present of the number of stems (also the percentage of stems) of each diameter class which can be expected in a crop of a given average diameter. It is perfectly simple to explain to any one when at the table, but my experience has been than in 3 months' time he has reverted to the old confusion. The figures we have given are based, I think, on inadequate data, but as for a good many other things that I have been responsible for here, I consider that the first step is the important one and as soon as people have got something to criticise, it is always possible to improve on it.

The question of comparability of plots I ought to deal with more fully. There are two ways of dealing with this question, one is to find a uniform plot, to be sub-divided into two pieces more or less adjoining with a narrow strip between and compare the consequences of a different thinning in each ; the second alternative is to choose in different places plots acceptable on a given standard, thin them in the desired ways and then compare the thinning method by grouping all the plots under one kind of thinning. This second method is virtually what we are doing at present. For certain of our main species we have a large number of plots scattered about in which different thinning grades have been tried. The number of plots required for comparison of such averages is very large owing to the difficulties of getting satisfactory mean values. We have to compare that difficulty with the difficulty of finding suitable areas in which we can guarantee initial comparability. The same point has come up in all forms of crop experimental work. It is one of the points in which our work varies so largely in degree as to differ almost in kind from the agricultural work on which we base most of our experimental technique. We deal with a small number of plants scattered over large areas in which big differences in quality often occur. We have been testing during the last few months all the plots we can get hold of for this initial comparability. We have looked at specimens from Bihar, from Burma, we have looked at *Gmelina*, teak and *sal* plots in Bengal, as well as *sissoo* plots in the Punjab, and we find as a rule that out of a set of four plots perhaps two were acceptable as comparable while the other two could not be included in the same series, the fact that they had been selected with special care notwithstanding. I think we shall have to continue searching for suitable areas and in that we must have the co-operation of the territorial staff. For the next year or two we must see what can be done, to see whether in actual practice we can use this method. If we cannot we shall be forced to the other method and that is going to mean more money and time. It is possible that we can work with different methods altogether but such are usually based on single measurements of trees and generalising from single trees to crops, an extremely dangerous thing to do. I have found some European authorities doing a good deal of it under the guise of "intelligent anticipation". I confess to having done the same thing in places in revising the deodar table.

I am asked how to determine the optimum crown shape. The work that has been done, as far as I can find out, is largely based on merely personal impressions. Everybody has an idea of what is a good crown and it can be checked up by the increment of the individual trees, to give the rate of growth for crowns of different sizes and shapes ; I think that is about the only line on which any attempts have been made to render the selection of optimum crown acceptable for research.

Mr. Howard.—Roughly, I have always found the ideal length to be 30 per cent. or 1/3rd. The tree that goes completely wrong is the deodar where it is nearly half.

Mr. Homfray.—I should like to refer to this question of initial comparability. We have practically 100 per cent. stocking in most of the plantations where plots have been laid out. If Mr. Champion is not satisfied with the plots we have laid out, we cannot lay out any better. The other point I should like to talk about is the question of undergrowth in plantations being increased by heavy thinning. At the last conference I put up a note stating that although we wanted to thin heavily we did not cut any of the suppressed and dominated stems because of the danger of increasing the climbers in the plantation. I am glad to tell you that since then we have done certain experiments on this point, thinning our plantations half with and half without removal of the dominated and suppressed stems, and doing a D grade thinning in the dominants, and in the areas in which all dominant and suppressed trees were removed, the climbers were far less than in the areas where they were left.

Mr. Champion.—I think there are also other ways of getting round the difficulty of initial comparability of plots, based on more but smaller plots. I suggest that in a good many cases sub-division may make it possible.

Mr. Laurie.—Is it possible to assess the quality of the plot from its height at an early age of say 5 years ?

Mr. Champion.—It is very doubtful. As usual, there is a choice of two evils. If there is an appreciable difference at 5 years, you must accept it ; and if subsequent differences do develop it cannot be helped even if it is recognised. This risk only points to the necessity of duplicating the work.

Mr. Laurie.—One point that has not been discussed here is the assessment of results. It would appear to be rather necessary that at different stages of the experiment some sort of estimate of the money value of the crop should be made, and for that it is necessary to have a definite timber classification according to the sizes and shapes of the logs that are sold in the market. Another difficulty is that timber classification is likely to change throughout the period. What is found unsaleable this year may not be saleable 40 years hence. We have an instance of that at Nilambur now. Formerly big logs were in demand but it is obvious that small sizes are becoming more in demand in the local markets. It seems that you have to make a guess as to what is going to be the best classification and you would have to stick to that throughout the investigation. Some money value would have to be determined in all these cases. These may be arbitrary but that appears to be the only way of giving some sort of answer to the question of the best methods of thinning.

Mr. Champion.—This difficulty of course has cropped up everywhere, and I think the general decision on it is that it is quite impossible to work on the money value. What we need is some sort of classification, some way of statistically expressing the general quality of the bole, and then to leave the actual interpretation including the derivation of money results to the occasion when the demand is actually made. It will occur quite possibly in the working plan but as long as we have an adequate description of the timber itself, a utilisation officer should be in a position to transfer it into timber assortments and price assortments. But until the necessity arises we would better leave them alone.

Mr. Howard.—I would like to add a word. It has been proved and has been admitted by probably the biggest man we have ever had on forest values, Max Endres, that a timber quality classification or volume is a far better method of value than money. So that if you classify your timber, the quality of the timber and its volume is your best measure of value.

Mr. Laurie.—At the beginning of this discussion, Mr. Howard stated the opinion that whatever you did to your crop the total production from the soil was approximately constant. What I would like to know is whether in a plantation if you remove all the trees that are right underneath the top canopy, will you put any extra increment on to the top canopy trees. They are not going to have any more room to spread their crowns in.

Mr. Howard.—I do not think the question has ever been fully answered but I believe the Swiss at any rate say that they always consider only the air and they never consider the earth. That in actual fact you are getting a certain amount of increment by taking away those trees, but that is merely an opinion that has been expressed. I have never seen anything proved at all.

Mr. Champion.—Our general opinion here is that it is very difficult to force increment in this way. Thus by removing one shoot out of two on a coppice stool you cannot force its increment into the remaining shoot.

Mr. Trevor.—I should be entirely opposed to any tampering with our present classification of thinning. It has been exceedingly uphill work to get the classification of thinnings accepted by the ordinary executive staff. I think under these circumstances we should do nothing to alter the conception of the classification of thinnings which we have been trying to instill into our students and into the executive staff of the Forest Department during the last 10 years. I quite agree that in the case of plantation crops, many of which have grown up since the first system of classification was made, they do not apply, and in those cases we can agree to adding a note to the classification, but so far as the classification itself is concerned I should be very sorry to see any changes made in it. In years to come when every single forest officer in India and Burma understands the classification of thinning and knows what a " D grade " and " C grade " means, then we might consider modifying the classification, if need be, but at the present moment I think it would be exceedingly unwise to alter in any way our classification of thinning.

Mr. Champion.—I would like to ask whether we should add this supplementary note for ordinary divisional use or only for research purposes. The question came up at the last conference and we decided as might have been expected that what was adequate for divisional use was not adequate for research purposes. This point has actually come up in divisional matter more than in our research.

Mr. Howard.—It depends entirely on how it is written. If it is in a completely simple form then personally I think it would be an extremely useful thing to have. We have got to do the work and the sooner we get to some standard method of saying what we have to, the better.

Mr. Champion.—Might I suggest a practical way of dealing with the matter ? We had a committee dealing with statistical research which amounted really to amendments to our present *Statistical Code* for research purposes. We have our research classification at the end of that, and probably our best procedure will be for us to add a section for research work. It could be circulated to those who have opinions on the point and if it is found satisfactory we shall no doubt hear about it, and we could publish it as a special pamphlet. It will be up to the territorial staff to suggest modifications.

Mr. Chaturvedi.—In connection with this question of initial comparability, I may mention that when studying research work in Sweden I was told that their practice was not to insist on initial comparability but to find out exact initial differences, because they found it equally difficult to lay out initial comparability plots so that they have devised methods by which they measure the magnitude of the difference. They lay out a plot, watch its progress for 5 years, and then so obtain a measure of the initial difference between the two.

ITEM 19.

Revision of Code Form 16 and 16 A dealing with progress in regeneration.

This subject was brought forward in the course of discussing the action taken on the 1929 resolution on the subject. Mr. E. A. Smythies was asked to collect a committee and make proposals for meeting the difficulties experienced in several provinces in filling in the simplified form agreed on in 1929, particularly with regard to giving area figures for completed regeneration each year. It was found that the real need was for the modification of Statement XII of the *Annual Return of Statistics,* since it had already been decided that Code Form 16 may be in any form convenient to a province provided it gave the necessary figures for Statement XII. The Committee proposed such a modification as described in the debate (see below). No resolution was considered necessary.

Report of Committee.

A Committee of the Silvicultural Conference considered the information required for Statement XII of Annual Return of Statistics relating to Forest Administration in British India prepared by the Inspector-General of Forests.

It was considered that the area regenerated during the year by mainly natural methods was difficult, if not impossible, to fill up correctly, and it was therefore considered preferable to shew the total area under concentrated regeneration.

It was therefore decided that Statement XII could be better presented in the attached form and further that Provinces should be permitted to use this single form, or to modify existing Code Forms 18A and 18, (16 and 16A) as they consider most suitable for local conditions, provided that the information required by the Inspector-General of Forests for Statement XII is given clearly and concisely.

Proposed headings for Statement XII.

Province.	Area under concentrated natural regeneration during the year.	Area regenerated mainly by coppice during the year.	Area artificially regenerated during the year.		Total cost of regeneration operations during the year.
			In existing tree forest.	Afforestation.	
1	2	3	4	5	6

Column 2.—Includes all parts of Periodic Blocks I in process of natural regeneration.

Column 3.—Shows coppice coupes felled during the year.

Column 4.—Includes only those plantations first formed during the year.

Column 5.—Includes lands artificially converted to forest during the year.

Column 6.—Includes all costs of obtaining and of tending natural or artificial young corps, *i.e.* the provincial total of budget sub-head B. VIII (or A. VIIIe).

OF DEBATE.

(1) *Debate on 29th October 1934.*

Mr. Champion : (Reporting action taken on the 1929 resolution). The resolution recommended that a single simple 6 column form be substituted for the existing form, leaving Provinces to supplement the information as found most suitable for local requirements. Chapter III of the Annual Report was to be revised to agree with the new form. After correspondence with Bombay, Burma and Madras, the Government of India decided that no further action was called for as the President, Forest Research Institute and College, was receiving the necessary statistics for compilation in his all-India returns (Statement XII of the *Annual Return of Statistics*).

Mr. Trevor : I think you are in a position to reconsider the whole question. It was merely mentioned at the Board of Forestry and no definite proposal was put up to the Board regarding these two forms. The Chief Conservator of the United Provinces was told that he could modify his form in any way provided the necessary information appeared. These forms have led to a great deal of trouble as originally compiled by the Silvicultural Conference and now certainly require complete revision. One of the forms said " Areas regenerated during the period " but it is sometimes quite impossible to arrive at any figure for this. I think it would be a good thing if this conference appointed a committee to consider the whole question.

Mr. Smythies : At the last conference we discussed this, and the conclusion was that the provinces do not want Statement XII at all.

Mr. Trevor : Perhaps the committee might consider the modification of Statement XII and then the Provinces would only need to supply the information required for the modified statement. I think we must have some statement dealing with regeneration. I admit there are great difficulties but we are asked for this sort of information from all over the world—only recently from Japan—and we also needed them for the Empire Forestry Conference. I think something must appear. We need not necessarily show the area regenerated during the year, we might show the area under natural regeneration which is perfectly easy to give We have areas regenerated artificially that presents no difficulty and I must have those of course. Would Mr. Smythies be prepared to assist us in this matter by getting together a small committee to discuss Statement XII as to how it could best be modified in the statements of provinces ? (Mr. Smythies agreed.)

(2) *Debate on 3rd November 1934.*

Mr. Trevor : This Form 16, specially column 2 shewing area naturally regenerated during the year, has given a great deal of difficulty, and it is really impossible to show in this column the real state of affairs. I was approached by the United Provinces and a committee of this conference has been held to consider what information I need for my Statement XII which shows progress in regeneration in India during the year. I have agreed to modify Statement XII, and what I now require is that column 2 becomes " Area under concentrated natural regeneration during the year ", and there is a note at the bottom " Includes all parts of Periodic Block I in process of natural regeneration ". It is perfectly easy to get that figure.

Next, Column 3—" Area regenerated mainly by coppice during the year ". That will have the area of your actual coppice felling which is also perfectly straightforward. It also has the advantage that when I am asked by Japan or some other countries how much coppice felling is done during the year, I have the figure in that form and I do not have to send a circular to everybody to ask for the information.

The next column—" Area artificially regenerated during the year "—is divided into two parts, " in existing tree forest "—that would include all clear fellings with planting, and generally all plantations made in areas which are now forest as opposed to the creation of new forest, which will come under the next column under " afforestation ". The last column gives as at present the total cost of regeneration during the year.

This revised statement will give me all the information I require on the subject to enable me to answer the enquiries from time to time I receive. I propose now to send the suggested alterations to all heads of departments asking them to issue such orders as they think fit. There is no necessity to pass a resolution.

ITEM 20.

Management and Improvement of Forest Grazing.

Papers were contributed from the Central Provinces, Bombay, and Madras, and a summary (see below) circulated before the conference. A relevant extract from a Madras Working Plan (p. 246) was also circulated.

The subject was introduced by Mr. H. C. Watts (Central Provinces) and a long and interesting debate (p. 250) ensued, representatives of most provinces taking part.

The following resolution was proposed by Mr. Watts, seconded by Mr. Deogan (Punjab) and passed by the Conference :—

RESOLUTION ON ITEM 20.

Resolved that—

This Conference considers the development of investigations for the improvement of forest grazing a matter of the utmost importance and therefore recommends that the experiments started in several provinces since 1929 should form the subject of an all-India investigation. In the co-ordination and developments of these experiments the assistance and collaboration of the Agricultural Department should be invited, particularly with regard to a systematic ecological study of the grasses and their nutritive value.

This Conference also considers that the reduction of the herds of inferior cattle and the encouragement of stall feeding and the control of grazing are the only final solution of the grazing problem in India.

Report of Silviculturist, Forest Research Institute of action taken on the Resolution passed by the 1929 Conference.

The resolution recommended systematic experiments in co-operation with the Agricultural Departments and was brought to the notice of all Local Governments for such action as they might consider necessary.

In the Central Provinces an extensive investigation was commenced in 1931 involving collection and weighment of grass in nearly 700 plots in 7 divisions under different conditions, the project being drawn up by the Forest and Agricultural Departments. The data collected that year failed to give the required information mainly owing to lack of comparability among the plots, though some useful data were collected. A new series of plots was selected in Yeotmal division for 1934, utilising the experience so gained.

Some developments have occurred in the United Provinces notably the introduction of fodder trees species in grazing areas temporarily closed for plantation work. In the Punjab, much propaganda has been done to popularise stall feeding but with no result ; some small co-operative experiments with the Agricultural Department give no new information.

Bengal has found Napier grass (*Pennisetum purpureum*, Schum and Thom.) suitable as a soil cover crop for *sal* plantations provided it is kept cut ; it is a good fodder grass. Rotational grazing has been prescribed in the new working plan for Puri division.

PAPER (I).

Compiled by P. N. Deogun, *Experimental Assistant to Silviculturist, Forest Research Institute.*

(*i*) *The Central Provinces.*—A scheme to determine the yield of grazing areas was drawn up by F. J. Plymen, (Director of Agriculture) in 1931 who recommended cutting at intervals namely mid-August, 1st October, mid-November, and end of growing season say January, and a single cutting at the end of the season, the two treatments to be repeated 10 times over 3 different types of soils, namely good valleys, hill sides, and the high lying lands, so that in all 60 plots were required. The above mentioned treatments were recommended to be repeated on overgrazed areas if possible.

Plots were laid out in 7 divisions but the scheme was not fully carried out.

Item 20.]

The following is the gist of the conclusions drawn by Mr. Tara Singh, Silviculturist, C. P. :—

1. Closure to grazing helps in the improvement of a forest pasture.

2. The period of closure to effect recovery of an grazed area varies from 1 to 5 years depending upon the condition of the grazed area.

3. Closure beyond a certain period does not help in the further improvement of the grazing area.

4. Periodic cuttings during the year yield more total grass than a single cutting at the end of the growing season.

The scheme did not provide for the study of the following :—

(*i*) Effect of continuous grazing.

(*ii*) Time taken by over grazed areas to recover.

(*iii*) Period of rest required by grass lands after continuous grazing of 1, 2, 3 or more years.

(*iv*) If this period of rest could be done away with by carrying on rotational grazing during the year.

As a matter of fact grass cutting can hardly compare with grazing.

The experiments under the scheme can only give yield of grass from periodic and annual cuttings for different types of areas.

A possible figure for grazing incidence can also be worked from the total periodic yield and the requirements of cattle (as supplied by the Director of Veterinary Services, C. P.), provided the grazing is rotational and not continuous.

In carrying out the experiment in different divisions the number of variables such as the density of overhead cover, the grazing incidence for the plots, the period of grazing before applying the closures, in addition to the variables to be studied, *viz.*, the effect of single and periodic cutting the effect of closures on the annual yield of grass, on different types of grazing grounds was unnecessarily high so that it was not possible to compare the results freely.

The results of one year's working (1931-32) show more or less definitely the superiority of periodic cuttings over a single cutting.

Another conclusion which can be drawn fairly accurately is that there is a limit in the improvement of a pasture resulting from the application of closure. If the closure is continued for a longer period the pasture instead of improving deteriorates. In the case of good and medium types of grass lands this period worked out to 3 and 4 years under periodic and single cuttings respectively.

The results on poor soils were not consistent. In some plots the yields fell off after 1 year closure but others indicated the best period of closure as 4-5 years, for poor soils.

In accordance with a revised scheme the provincial silviculturist in December 1933 laid out in the Yeotmal division 165 square-chain plots in which weighments will be carried out annually over a period of at least five years. The scheme is somewhat complicated and its details can hardly be fully explained in a short note : but the main lines of the investigation are as follows :—

(*a*) *Incidence.*—For purpose of incidence, plots are classified as (1) very heavily grazed, (2) heavily grazed, or (3) moderately grazed. No plots were laid out in lightly grazed areas with which the experiment is not concerned. The general numerical grazing incidence in most of the compartments in which the plots were laid out is about one acre per head of cattle. But it was considered preferable to rate the incidence in each plot by an ocular estimate of the conditions in the plot itself rather than to depend on the numerical grazing incidence for the whole compartment or grazing unit; as grazing incidence is unlikely to be uniform throughout a compartment, but is sure to be much heavier in the more accessible parts of it.

(*b*) *Topographical position.*—Plots have been classified as of good, medium, or poor productive capacity, having regard to depth and nature of soil, exposure, overwood, etc. Plots have as far as possible been laid out in open areas with a minimum of overwood, as any changes in weighments will be more marked than in areas where the grass is only scanty.

(*c*) *The effect of continuous grazing.*—In areas which have hitherto been closed to grazing for a number of years and which will now be opened, sets of eight square-chain plots A-H, as comparable in all respects as possible, have been demarcated. Wherever possible, initial comparability has been tested by carrying out a preliminary weighment of the grass in all the plots at the time of laying out in December 1933. In 1933, plot A was fenced ; the remaining plots will remain open till December 1934, when the grass in plot A will be weighed and plot B (grazed for one year) will also be fenced. In December 1935, plots A and B will be weighed and the fence from plot A will be moved to plot C (grazed for two years). Similarly in 1936, the fence from plot B will be moved to D (grazed for three years) and the yield of C and D recorded. Thus a series of weighments of comparable plots open to grazing for periods of from 0 to 7 years will be obtained, and the results checked by comparison with other sets in the same compartment and in other compartments in various localities.

In Yeotmal, coupes remain open to continuous grazing in most localities for ten years only. To study the effect of grazing on the production of grass during the second 5 years after opening, in compartments which have already been open to 4 or 5 years, separate sets have been laid out in such areas on the same lines as the sets laid out in coupes which have been closed and are now being opened.

(*d*) *Effect of closure.*—This is a more simple matter. A number of sets of plots, with 3 plots in each set, have been laid out in areas that have been grazed for 5 years or for 10 years. The plots have been fenced and will now be closed to grazing and the grass weighed every year in each plot for a period of five years. The weighments should give some indication of the influence on the pasture yield of closures of various periods up to 5 years, in areas previously grazed for periods of 5 or 10 years.

(*e*) *Grass species.*—As grasses vary greatly in nutritive value, a rough ocular estimate has been made at the time of laying out the plots of the proportions of each variety of grass in the yield of each plot. Similar observations will be made in future years and any changes in the species will be recorded.

(*f*) *Seasonal variation.*—To ensure comparability of results, weighment in all plots will be carried as far as possible on the same dates each year. Changes in the climate or the rainfall from year to year are likely to influence results ; thus in a year of heavy or late rains, the grass weighments are likely to be greater than in a dry year. To check possible seasonal variations, a number of sets of check plots have been laid out in compartments which have long been closed to grazing and are thus not influenced by it. The grass in these plots will be cut annually on the same dates and any variation can only be ascribed to climatic changes. A similar variation in consequence of climatic changes is to be expected in all the plots.

(*g*) *Weighments.*—These are carried out in November or December. The grass is cut in the morning and weighed in the after-noon, after it has had time to dry.

Two sample forms are submitted, showing the way in which records of weighments, etc., are maintained.

Grass Experimental Plots laid out in Yeotmal Division, Yeotmal Range, to study the effect on the production of grass of continued grazing the next eight years in coupes which have already been open to grazing for ten years and which are to remain open. **TYPE B I.**

Name of Unit and Felling Series.	No. of coupe.	Locality.	Number of		Grazing incidence in the unit.	Anticipated incidence in the plot.	Productive quality of grass and soil.	Over wood.	Brief description of grasses.	Date on which the coupe was opened.	Year in which each sub-plot is to be fenced.	Result of weighment.				Remarks.
			Plot.	Sub-plot.								Year.	Weight in lbs.	Year.	Weight. in lb.	
Umri Kharad Felling Series.	**3**	**About ¼ mile from the north boundary of coupe 3 along the cart track from Pardi to Saykhed. *Via* Umri and then to East about 300 yards.**	23	A	1·6	V. H.	Moderate Soil Black cotton of fair depth with lime kanker.	5 to 10 %	Mushan 75 Marbel 5 Kunda 10 Gondli 10	1st January 1923.	1933	1934		1935		Sub plot A is common to plot 24 also. It has been fenced and will remain fenced.
				B							1934	1935		1936		
				C							1935	1936		1937		
				D							1936	1937		1938		
				E							1937	1938		1939		
				F							1938	1939		1940		
				G							1939	1940		1941		
				H							1940	1941		1942		

(*ii*) *Bombay.*—Burns carried out certain experiments in the improvement of grass lands near Poona from 1926—1932 over an area of 40 acres, which formed part of the lower slopes of trap hills, at an altitude of about 2,000 feet, and an average annual rainfall of about 25 inches. The soil varied from mere gravel to deep medium black soil which was badly eroded in places. The general ecological type of vegetation was midway between mixed deciduous and thorn with *Boswellia serrata* as the prominent tree. The trees were sufficiently widely spaced to permit of full growth of grass. *Andropogon annulatus, A. monticola, Panicum isachne, Iscilema anthophosoides* formed the important palatable grasses and *Andropogon contortus, Aristida* spp., etc., the bad grasses in various proportions.

The area was divided into 4 blocks of 10 acres each, but the blocks were not strictly comparable.

According to the original scheme one of these blocks was grazed all the year round, the second and third were closed annually and biennially till the young grasses had made their growth (till the middle of August) and grazed afterwards, and the fourth was closed and cut for hay annually and grazed afterwards continuously. The number of animals grazed at the beginning was 1—5 per block or at the rate of one animal to 2½ acres (16 in all).

In 1928 the grazing plan was altered and all the animals were grazed in one herd and moved from block to block, keeping one block for cutting of grass after seeding for hay and silage with grazing afterwards, so that the 3 grazed blocks were treated on a system of rotational grazing. In 1929 the number of cattle was 30 but in 1930 and onwards it was reduced to 20 as a more suitable number for the area. Inspite of the fact that the total grazing units (number of days grazing done × number of cattle) under discontinuous grazing were more than under continuous grazing the condition of the grass land showed a great improvement.

Water and rock salt were provided for the cattle. Salt was also used to attract cattle to the less palatable grasses. In 1930 two acres in each block were set apart and grass therein cut at each time the animals were shifted, to get an idea of the quantity of grass removed by the cattle.

The following conclusions are drawn :—

1. *Continuous versus rotational grazing.*—Continuous grazing reduced the proportion of good grasses, helped the production of bad ones and the production of spiny weeds. Rotational grazing (shifting of cattle in one herd from block to block after intervals of 1 to 5 weeks), on the other hand helped both the cattle as well as the vegetation which was clear from the 25 per cent. gain in the weight of the cattle, in 5 months (July to December), and the increase in the proportion of palatable grasses. The perennial grasses produced tender foilage after each rest period and the annuals got full chance to develop and seed.
2. *Grazing incidence.*—With rotational grazing two acres per animal (cow) were found quite sufficient to maintain the health of the animals provided they were stall fed with hay and silage made from part of the 2 acres from March to June, when they could be allowed to roam about in the mornings, picking up what they can get.
3. *Quantity of grass consumed by each animal.*—One animal (cow) was found to consume about 45 lbs. of grass per day.
4. *Effect on regeneration.* (1930-31).—The tree seedlings present in all plots were not touched by the animals at all as there was sufficient grazing for them.

(*iii*) *Madras.*—North Coimbatore Working Plan paras. 656—661 prescribed certain experiments for the introduction of better fodder grasses, *viz., kolakuttai* and *kikiyu*. The idea was to lease out certain areas to villagers who would introduce such grasses on their own.

Experiments with *kolakuttai* were carried out in 3 ranges. In one range experiments were carried out for 3 consecutive years.

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Experiments with *kikiyu* were carried out only for one year at one place when drought killed the rhizomes planted.

The net result of the experiments was that for the successful introduction of these grasses, the area must be cleaned and ploughed which means an expenditure of about Rs. 10 per acre and so is not possible.

The villagers do not show any interest and it will not be possible to induce them to adopt such methods.

NOTE.

EXTRACT OF PRESCRIPTIONS REGARDING ROTATIONAL GRAZING FROM THE NORTH SALEM WORKING PLAN, BY MR. C. R. RANGANATHAN.

Method of Treatment.

Grazing is at present regulated by licensing cattle to grass in the forests, on payment of the prescribed fee. For the same class of animals the grazing fee is uniform throughout the division and the grazing permit confers the right to graze in any part of the division. Apart from the indirect control over the numbers of cattle grazing in the forests effected by the levy of fees, the present policy of Government does not contemplate any direct regulation of the number of animals that may be admitted into the forests. The prevailing rates of grazing and penning fees are :—

Cows and bulls	0	8	0	per head.
Buffaloes	0	12	0	per head.
Sheep	0	4	0	per head.
Penning cattle	1	8	0	per head.

The position as regards grazing is unsatisfactory in several respects, but we do not propose any alterations in current practice for two reasons. In the first place, it is beyond our competence to suggest a revision of the principles of management of grazing which have been laid down by Government, and, secondly, the question is best dealt with from the presidency point of view, especially in view of the recent tendency to regard the grazing fee as a species of provincial tax, rather than as the price of goods consumed.

Rotational grazing.

It is now generally recognised that, repugnant as grazing is to intensive silviculture, an important object of management of forests in the drier districts is to provide grazing for large numbers of cattle. In North Salem, as in other similar divisions, the large grazing revenue realised and the comparability poor grazing available for the cattle imposes on the Forest Department an obligation to attempt to improve grazing facilities. Direct measures aiming at the introduction of good species of fodder grass cannot be adopted in North Salem, as the Hosur plateau (where such methods have the best chance of success) is overgrown with *Lantana* and the removal of this pest and its replacement by grass would not be only difficult but very expensive. Moreover, experience has shewn that in the artificial introduction of grass, ploughing and fencing are essential conditions of success and in forest areas the practicability of such operations is very limited.

Recent researches in pasture management have indicated a method of improving grazing, which does not involve any outlay of capital and which can be applied to forest conditions without serious difficulty. This new method is called rotational grazing. The principle of rotation consists in moving a limited number of cattle from block to block within an allotted area at short intervals. This system of pasture management was developed in Germany during the war and it has since been tested and adopted by several other countries.

According to McConkey (*Recent Advances in Pasture Management*, by McConkey, published by the Empire Marketting Board, July 1931), rotational grazing is applicable to areas of low rainfall. He says that " in areas of low the indigenous grasses depend on reseeding to a great extent to tain themselves in competition with other species of uneconomic plants ; this is in contrast to the vegetation of humid areas which relies on vegetative reproduction to a greater extent, long creeping stems, stolons, etc. Heavy grazing is essential on this type of pasture to ensure maximum nutritive returns ; not so in the dry areas of the Empire where the natural climax cover is an open " bunch grass " formation which, when overgrazed and no provision for rotation and rest period are used in the management, rapidly deteriorates to a surface bare of valuable pasture grasses, and is quickly invaded by moss, sagebrush, cacti, and hard xerophytic plants of low pasture value ". An interesting experiment in the improvement of forest grassland in the Bombay Deccan was carried out by Dr. W. Burns, Economist Botanist to the Government of Bombay, and the results are published in the *Indian Forester* (Volume LVII, 1931, pages 601—609). His conclusions are :—

(*i*) The best way to make full use of grassland is to take advantage of the gregarious habit of cattle and graze a large herd in one restricted place rather allow them to wander at will over a big area. Where fencing is impossible such restriction will have to be done by herdsmen.

(*ii*) For such lands as were dealt with in the experiment (which are similar to the forests of the working plans area), one animal to two acres seems about right. This ratio applies to the whole rotation system and not the sub-blocks grazed over periodically. The actual density in the sub-block occupied by the cattle will of course be this ratio multiplied by a number of sub-blocks in the rotation system.

(*iii*) In practice the blocks will obviously have to be large, *i.e.*, hundreds instead of tens of acres.

(*iv*) In practice the length of time that any sub-block shall be grazed will have to be arbitrarily fixed. This period will have to be determined by experience. One can only say that in the first instance it will probably be wise to err on the side of too short rather than too long an occupation of the ground.

Dr. Burns found that continuous grazing by even a small number of cattle is far more damaging to vegetation than grazing for shorter discontinuous periods by a large number of cattle. The adoption of rotational grazing resulted in his experiment in an increase in the carrying capacity of the locality, and in the improvement of the quality of both the grass complex and the tree crop.

The principle of rotation has been tested from several points of view. Experiments at Aberstwyth, at Cambridge and in Finland under controlled conditions have shown that under rotational grazing (*i*) the live weight of the grazing stock is increased. (*ii*) the amount of cut fodder per acre progressively increases as the period of rotation rises from one to three weeks. (See McConkey's pamphlet cited above.) The shorter the interval of rest, the less pronounced were the benefits of rotation found to be.

These striking results provide a strong case for the introduction of rotational grazing in our forests. The method involves (*a*) restriction of the number of cattle grazing over a given area, (*b*) the allotment of a definite area for grazing by the prescribed number of cattle, and (*c*) the alternation of the stock from paddock to paddock in strict accordance with a pre-determined time-table. The closure of specified paddocks to grazing and the limitation of the numbers of cattle permitted to graze within the rotation system are in apparent (but not real) conflict with the grazing policy of Government. It would be a mistake to suppose that the adoption of rotational grazing is in effect merely the revival of the now abandoned block system of grazing. It is not intended to confine the cattle of a particular village to a particular grazing ground, nor is it intended to portion out the available pasture among the various villages. Rigid control over the number and movement of the cattle is of course inherent in the new system, but such control is primarily in the interests of the cattle, and is inevitable in any measure calculated to improve pasture or live stock. To begin with, the restriction will no doubt have to be imposed officially and will be resented by the graziers, but if the advantages claimed for rotational grazing are realised in large scale practice, we may naturally expect the graziers to submit willingly to, and even apply voluntarily, the necessary regulation.

In any event, the system deserves to be tested fully under practical field conditions. The obvious places for carrying out the proposed experiment are pens. The District Forest Officer has the power to fix number of cattle that may be admitted to any pen. One essential condition of success is thus readily realised. Moreover, since the same cattle are stalled in a pen for prolonged periods, control over their movements is easily exercised and observation of their condition easily made. Finally, in pens a positive inducement to submit to the regulations of rotational grazing can be given by reducing or waiving the penning fees in the pens selected for the experiment. The system has not yet been tried under forest conditions on a large scale, and we consider it safer, and administratively more convenient, to limit the experiment in rotational grazing to two selected pens in the first instance. When the experiment is proved to be a success, and the ryots are convinced of its advantages it will not be difficult to extend it to other pens and even to the case of day to day general grazing in the forests.

We propose to locate the sites of these experiments in the Cauvery valley. The forests of this region have been fully described under the head of the " The *Hardwickia binata* type " on a previous page. Mention has been made of the regular occurrence of fire in this type of forest, of the inadequacy of mechanical methods of fire protection to cope with determined incendiarism, and of the ineffectiveness and aggravated peril of punitive measures, such as prolonged closure to grazing. Our powerlessness to prevent fires in this locality may be traced to the cleavage that always exists between departmental aims and popular interests in areas where grazing is practised on a large scale. It is very doubtful whether any material improvement of the forest will take place in the unlikely event of a complete cessation of burning. This, however, is not a contingency we need seriously consider. Grazing will always be practised here, and it would be practically impossible to forbid grazing in these tracts, and in our opinion, unwise to attempt to do so. The best and the most profitable object of management for these forests is to treat them primarily as grazing grounds. If this is done, the prevalence of fire may be faced with equanimity. In grazing grounds intensive grazing is itself the best form of insurance against excessive fire. The introduction of rotational grazing will, we hope, ensure the intensive grazing of all the areas brought within its scope, and will, further, bring about a progressive improvement in the quality and edibility of the grass complex, thereby removing the commonest incentive to burning, namely, the replacement, for however, short a period, of the tough inedible grass stems with tender, succulent shoots. A tendency to less and less burning will thus probably automatically result from adoption of the new system, but this improvement is likely to be a slow process. Meanwhile, there seems to be no objection to such burning as is necessary in the interests of grazing within the rotation system being done by the graziers under departmental supervision. Rotational burning may then be regarded for the present as a desirable auxiliary to rotational grazing.

The following prescriptions shall be carried out during a continuous period of three years beginning with the year of introduction of the working plan. At the end of this period a detailed report on the work done, results achieved and difficulties encountered shall be submitted by the District Forest Officer and the Conservator of Forests, Salem Circle to the Chief Conservator of Forests for orders on the continuance, extension or abandonment of the system of rotational grazing :—

(*a*) *Choice of site.*—Two pens will be taken up for the experiment, namely, the Mosalamaduvu pen in Woodapatty reserve and the Padigatt pen in the Natrapalayam reserve. Both these pens are situated on the Cauvery and their water supply is therefore assured.

(*b*) *Capacity of pens.*—The capacity of each of these pens will be fixed at the equivalent of 1,000 cow units. Every endeavour should be made to attract the maximum number of cattle to the pens, but the capacity fixed should not be exceeded. As an inducement to the graziers to stall their cattle in the experimental pens, and to submit to the regulations prescribed below, it is suggested that the penning fees should be partly or fully waived in respect of cattle penned in them.

(*c*) *Rotation blocks.*—According to Dr. Burns, an area of 2 acres of the type of forest dealt with in this experiment is sufficient allotment for one cow. An allowance of 3 acres per cow-unit should therefore probably be a safe figure. A block of 3,000 acres of forest is accordingly allotted to each pen. These blocks are indicated on the management maps. The boundaries of the blocks shall be demarcated on the ground by means of stone cairns, or otherwise, where natural features do not form the boundaries. It is essential that the limits of the rotation blocks should be clearly identifiable by the graziers.

(*d*) *Paddocks.*—Each rotation block shall be divided into three paddocks of more or less equal area, conveniently disposed round the pen, as shown on the management map. The limits of the paddocks shall be clearly demarcated on the ground (where natural features are not available) by means of cleared lines and stone cairns.

(*e*) *Period of penning.*—The period of penning shall not commence before the 1st of June and shall not extend beyond the end of January. These dates follow usual practice and involve no hardship. It would be an advantage to adhere to a fixed time-table and the District Forest Officer should endeavour to get the cattle stalled in the pens as early in June as possible.

(*f*) *Rotation of stock.*—Each paddock shall be open to grazing in rotation for a period of one month only and enjoy rest for a period of two months. This time-table shall take effect from the 1st of June or any later date on which the pen begins to function. Assuming that the pen begins to work on the 1st of June, Paddock I in either pen will be grazed over throughout the month of June, Paddock II during July and Paddock III during August. At the end of this cycle of rotation, *i.e.*, in September, Paddock I will be brought into use again, and so on as long as the cattle stay in the pen. The object of this rather rapid rotation is to ensure that the cattle graze over the entire rotation block during the first rainy season of the year, so that the grass does not become tough and inedible before the cattle get to it, as it might become under a longer rotation cycle. The paddocks closed to grazing must be clearly marked off by means of red sign boards. It is of the very essence of the system that promiscuous grazing should not be permitted. Grazing outside the rotation blocks should also be strictly discountenanced. If experience or unforeseen events show that the area allotted to each block is insufficient to provide sufficient grazing for 1,000 cattle, the District Forest Officer may, with the approval of the Conservator, either reduce the number of cattle admitted to the pens or suitably increase the area of the rotation blocks. It will be within the discretion of the District Forest Officer to commence the grazing in a year in any paddock, but having once gone through a cycle of rotation, the same order shall be adhered to rigidly during that year.

(*g*) *Survey of grasses.*—A proper appreciation of the advantages of rotational grazing is impossible without a comparative study of the grass complex, as well of the tree flora. A preliminary survey of the grasses occurring in the rotation blocks must be made and the survey repeated year after year till the conclusion of the experiment. A similar survey of the tree crop with special reference to the presence of seedling regeneration should also be undertaken. This work is best done in consultation with the Provincial Silviculturist and with the co-operation of the Government Systematic Botanist at the Agricultural College at Coimbatore.

(*h*) *Rotational burning.*—In January, towards the conclusion of the first year's experiment in rotational grazing, the rotation blocks shall be carefully inspected by the Range Officer, and the patches where the grass stems are tall and tough shall be burnt by him with the help of the graziers, as early as the grass will burn. This work will be repeated every year till the conclusion of the experiment.

(*i*) *Condition of the cattle.*—Although a quantitative assessment of the condition of the cattle subjected to rotational grazing is not feasible in an experiment of this kind, general observations on the relative condition of the cattle at the beginning and end of each year's experiment should be recorded in the Control Journal.

(*j*) *Control.*—In addition to a Record of Works (following the sample form given in the Appendix), the District Forest Officer will maintain plot files for the experiment on the lines adopted for similar experiments by the Provincial Silviculturist.

Report of Debate.

Mr. Watts : I propose first to read resolution we passed in 1929, then to summarise the action taken during the succeeding five years to give effect to that resolution in the provinces where grazing is an important problem, and lastly to make suggestions for the future development or co-ordination of such action.

The 1929 resolution was as follows :—

> " Resolved that Indian grazing grounds cannot be substantially improved without spending money and without control over the grazing. This is a branch of the more important problem of improving the cattle ot India on which the Royal Commission on Agriculture lays such stress. This conference recommends that systematic experiments be carried out in close co-operation with the Agricultural Department to discover the methods of improving different classes of grazing grounds and the cost of such improvements.
>
> Indiscriminate grazing should be replaced by stall feeding as much as possible."

The recommendations regarding the improvement of the breed of Indian cattle and the replacement of grazing by stall feeding are perhaps little more than the expressions of pious hopes, likely to be fulfilled only in a very distant future. The suggested experiments into methods of improving grazing are a matter of more practical interest and I propose to summarise the work undertaken in various provinces. I may take my own province, the Central Provinces, first.

The 1929 resolution lays great stress on the matter of the cost of such experiments and the conference felt that the Forest Department cannot fairly be called upon to meet such expenditure in a matter that is not primarily forestry. But in the Central Provinces, at any rate, it is not possible for us to adopt such an attitude. This will be understood when I remind you that grass and grazing provide one-third of the total revenues of the Forest Department in the Central Provinces and that this grazing revenue, which amounts to about 15 lakhs of rupees, is somewhat greater than the average annual surplus of the department. In the Central Provinces, many so-called forest areas are, and always will be, of far greater value as grazing grounds than for producing timber or fuel. It may be argued that the Forest Department is not the proper agency for the control of such lands but against this it must be remembered that it is precisely the moderately heavily grazed forests in which there is the heaviest demand for the poles and small fuel. It is difficult to suggest any other agency which could properly regulate the grazing even where the forest are unworkable, but the disforestation of such areas has been suggested and is certain to become a leading question under a reformed constitution. The Indian politician is sure to ask us what the Forest Departments have done to justify their collecting 15 or 20 lakhs annually from the cultivators for their grazing and how much of that revenue we have devoted to the provision of the grazing. If we are in a position to say that we have at least done something and if we can point to the experiments undertaken, we shall be far better able to justify our stewardship than if we have nothing to show.

The Local Government in the Central Provinces recently ordered that all reserved forests should be reclassified according to their relative importance for

-------- timber or for providing grazing. The classification adopted is somewhat similar to that adopted in Switzerland, to which reference was made in the last conference. In the timber forests, grazing incidence and closures are to be regulated strictly by the silvicultural demands of the forest, while in the areas classed as pastures, a heavier incidence will be permitted, but rotational closures are to be prescribed with the sole object of improving the pasture. I should perhaps point out that in the Central Provinces grazing is everywhere a privilege, not a right, and Government is therefore at liberty to impose any reasonable limitations or restrictions upon it. Such restrictions are imposed in a settlement undertaken at the revision of a working plan.

As Government has ordered rotational closures in pasture forests, it remains to be determined what rotational closures are most suitable, that is to decide :—

Firstly, for how many years can continuous heavy grazing be permitted in a pasture forest without the pasture yield being seriously reduced ?

Secondly, for how many years is closure to grazing necessary, following a period of years of opening, in order to result in an appreciable improvement in the pasture yield.

In an attempt to answer these questions, the Chief Conservator, in consultation with the Agriculture and Veterinary Departments in 1931 devised a scheme under which the grass was to be weighed in a large number of square chain plots be laid out in several divisions and the yields compared. The scheme has at least been useful as it has shown how many pit-falls are to be avoided in laying out such experiments : it has given no useful results, chiefly because the initial comparability of the plots received insufficient consideration and because Divisional Forest Officers are not in a position to devote sufficient personal attention to the selection and maintenance of the plots.

In consequence, the Central Silviculturist was consulted and he suggested lines on which the experiments might be improved or developed with at least some hopes of eventually providing some useful data. The scheme drawn up is rather too elaborate to describe in detail here but its main features are the following :—

(*a*) The effect of continuous grazing for five years is to be studied by laying out sets of six initially comparable square chain plots in an area which has been closed and is now to be open. In the first year, plot A (ungrazed) is fenced : The weighment in the second year shows the comparative effect of no grazing and one year's grazing, while subsequent weighments give similar data for longer periods of grazing. A large number of sets of similar plots have been laid out in various localities, to confirm the results.

(*b*) The effect of closure is to be studied by repeated weighments of the grass in square chain plots in an area previously grazed and now closed. The weighment in the first year gives the yield after one year's closure, in the second year, after two years and so forth.

The nutritive value of the grasses in each plot is to be studied by making an ocular estimate each year of the proportions of the various species. Weighments will be made as far as possible on the same dates each year and variation due to climate will be checked by laying out a number of check plots in areas permanently closed to grazing, in which any variation in the annual yield can presumably be attributed only to variations in seasonal climate.

Small samples of the grass in each plot will be collected and sent to the Agricultural Department for analysis of the nutritive dry value.

Bombay.—In Bombay, experiments into the effect of rotational closures have been carried out by Dr. Burns, the Economic Botanist, near Poona ; but whereas in the Central Provinces experiments by rotational closures are understood complete closure for a number of years followed by continuous opening for a number of years, the Bombay experiments have rather studied the effect of the shifting of herds of cattle from block to block after intervals of from one to five weeks during the same grazing season. These experiments were carried out over an area of 40 acres of open forest on the lower slopes of trap hills, not apparently very dissimilar from the areas in Yeotmal division where the Central Provinces experiments are being carried out. The area was divided into four blocks of ten acres each and various treatments were adopted. The experiments are stated to have shown that continuous grazing reduced the proportion of good grasses and increased the proportion of bad, whereas rotational closures increased the proportion palatable grasses and the weight of the cattle. With rotational closures two acres per animal was found sufficient to maintain the health of the herd.

Madras.—Based upon the conclusions drawn from Dr. Burn's experiments an interesting rotational grazing closure scheme has been experimentally introduced in the North Salem working plan in Madras. Two blocks, each of 3,000 acres have been selected and each divided into three paddocks of approximately equal area, the limits of each paddock being clearly demarcated : 1,000 cattle are to be permitted in each of these blocks, that is an incidence of 3 acres per cow will be permitted, and during the grazing period from June to December each of the 3 paddocks in each block will be open to grazing for a period of one month and closed for 2 months ; Paddock I will be grazed in June, Paddock II in July and Paddock III in August, after which the cycle will be repeated. An annual survey of the grasses will be made with the co-operation of the Agricultural Botanist and the condition of the cattle will be carefully recorded.

Two pitfalls suggest themselves in this scheme ; without fencing it will probably be very difficult to restrict the cattle to different paddocks in successive months ; secondly no control plots or paddocks appear to have been provided and it is difficult to see exactly how it is proposed to prove the value of the proposed rotational closures, except by the general observations which the Divisional Forest Officer is instructed to make.

The two main types of experiments which are being carried out are thus, the Central Provinces experiments into the effect of rotational opening and closures for a number of years, and the Bombay and Madras experiments which are studying the effect of rotational opening and closure during the same grazing season. In both these experiments the advice and assistance of the Agricultural Department have been invited. The United Provinces recent work in planting trees suitable for lopping offers a third line of work.

I would suggest that we should consider whether any of these experiments can be developed into an All-India investigation and whether any other provinces are prepared to undertake experiments similar to those which have been started in the Central Provinces, Bombay and Madras. The experiments are of a highly technical nature and can give satisfactory results only if carried out under expert supervision. I would therefore suggest that if these experiments are developed, the close co-operation of the Agricultural Department should be invited, and wherever possible the provincial Economic Botanist should be asked to collaborate in the scheme.

I suggest the following resolution :—

> This conference recognises that for many years the Forest Department has in many provinces derived a large revenue from grass and grazing but has been unable to carry out any systematic investigation into methods of improving the pasture. This conference considers the development of such investigations a matter of the utmost importance and therefore recommends that the experiments initiated in several provinces since 1929 should form the subject of an all-India-investigation, and that other provinces be invited to co-operate in the co-ordination and development of these experiments. The assistance or collaboration of the Agricultural Department should always be invited.

Mr. Garland : Dealing with these points more or less in the order in which Mr. Watts dealt with them, the first was the question of control of grazing grounds by the Forest Department. In Bombay there is literally no one else to do it. The alternative is the Agricultural Department but they are entirely advisory, having no territorial staff, so unless we control the grazing grounds, nobody will. On the question of classification, definite classification and separation of land for treatment as either forest or pasture is required. When I say separation I mean that either the grazing or the tree production must be entirely subsidiary. It follows that if you are going to treat on area as forest then the grazing must be very strictly limited and entirely under the control of the Forest Department, to be admitted or thrown out as and when they want. Where it is essential that grazing is provided certain forest lands must be allotted entirely to it and completely separated from the organised forests. With regard to the experiments of Dr. Burns, I have had the advantage of being associated with him when he was carrying them out. The Agricultural Department has issued various publications on the results, some of a semi-popular to and some more technical. Since these experiments, the only development has been that we have found that to try to control grazing on a really large scale is definitely a failure. You must separate off a herd of a reasonable size, say not more than a hundred head of cattle. The paddocks must be reasonably small and somebody must be in entire charge of the herds. He moves the herds from paddock to paddock as the season indicates.

One year there may be an early flush of grass and you want to move rapidly over all the paddocks ; another year it is slower ; similarly in different seasons of the same year. What is required is that for the normal year you have one or two spare paddocks in which grass is harvested and stored up against bad years. Then, when a bad year comes you have to use extra paddocks so as to give a greater area to counterbalance the poverty of the grass. An essential point is that it is an extraordinarily local problem. Conditions vary within 20 or 30 miles in different directions and these relatively small paddocks are essential. Adequate water supply is still more essential and both these things need money. Capital expenditure is necessary and we have now definitely come to the conclusion that all we are going to do is to have certain demonstration areas where we can find out exactly the cost and then use those example to give answers to people who say " What are you doing ? Why don't you do more ? " We want to be able to say, " If this and this is done we will give you good grazing, but somebody has got to pay for it. If you say the Forest Department, it must be understood that it will go out of our surplus ".

Mr. Allah Bakhsh : The position in the Punjab is very different from that in other provinces. Most of the forests are very heavily burdened with rights so that any control of grazing is wholly impossible. The public would not agree to controlled grazing. They would simply refuse to listen, because they have rights recorded in the settlements. The position is very nearly impossible.

Under the uniform system, the grass in our forests has considerably decreased, *i.e.*, with the closed canopy there is not as much grass as the villages used to get, so that the question is that you can either have grazing or timber production on the same scale as you can under the uniform system.

As divisional forest officer I had something to do with experiments that were carried out in Rawalpindi to see if we could improve the grazing. We felled an area heavily, opened out the crop, and fenced the area, and we found that in the second and subsequent years the quantity of grass was greater. Now we must first decide whether we wish to improve the grazing or to produce more and better timber. The only possible alternation is that we insist on better management of village forests pasture-*cum*-timber and provide all the grass the villager wants in his own village forest.

The whole thing is in the melting pot as far as the Punjab is concerned. The villagers refuse to have anything to do with closures. The hamlets are scattered all over the forests and everybody likes to have grazing at his door.

Stall feeding is entirely out of the question. Even in the forest the villagers do not send anybody to look after the cattle. They simply let them loose and let them wander about in the forest. I consider that it is important in this conference that some resolution should be passed to bring it to the notice of the Government that the question of grazing rights should be gone into.

The total money value of free or concessionary grazing in the Punjab is far more than in any other province, for the rights of the villagers are not so heavy elsewhere as in the Punjab.

There are only a limited number of forests, namely specially irrigated plantations in which the people have no rights, but the position in the high and low hills is extremely difficult.

Mr. Laurie : In Madras we have been doing certain amount of experimenting, trying to improve grazing areas by introducing better grasses. They have only been done on a very small scale, the chief grass used being what we call *Kollukattai* (*Pennisetum cencroides*), and although these small experiments were not financially successful in themselves, (they were not expected to be) there are indications that if done in a larger scale they would be quite cheap. In fact last year we got down to 4 rupees per acre including fencing and the demand for such areas is likely to be very great. In the experiment in N. Coimbatore Division which was done some years ago and which is only a small experiment, three cows and one calf were grazed on the area for one month and the owner paid 5 rupees. If you can get five rupees for one month for one acre it is quite useful. Well that is merely an indication that if we improve our grazing areas artificially they are practically certain to be financially a success. One of the foremost cattle breeders in South India has areas of similar types of forests on which he grazes his cattle and he introduces this grass over the whole of the area and he makes a financial success of it. The present policy of Government, of course, of charging a fixed grazing fee, makes it impossible to spend any money on improving our pastures but it seems likely that if we can artificially improve our grass we shall get a demand for the produce that will give a profit.

Regarding rotational grazing, Mr. Watts mentioned the prescriptions that have been suggested for N. Salem Division in Madras by Mr. C. R. Rangunathum. These have not been sanctioned as yet, but they have the general approval of the Conservator, I understand, and with a few modifications are likely to be sanctioned. Mr. Wilson, the Conservator, has suggested some other experiments in rotational grazing. He suggests that rotational burning of the bad patches of the grass might be a possible line of investigation. But can we improve the proportion of good grasses by rotational burning of bad ones ? The experiment suggested was that there should be four pens, and that two should be burnt during the south-eastern monsoon and the other two between the south-eastern and the north-western monsoon. That is just a suggested line of research. It should be remembered that if we do burn bad areas, unless we put in some better grasses, we are going still to get the bad grasses coming up again. There is no doubt that in many areas repeated burning increases the proportion of bad grasses. These grasses are eaten by the cattle but they are more filling than nourishing. Mr. Garland mentioned that in Bombay they found that small paddocks were better than large ones and that fencing was absolutely essential. In the prescription in the North Salem working plan the idea was that possibly by having very large paddocks with the pens in the furthest corners of them, the expense of fencing might be avoided, though it is not yet known if this method will be successful. I would like to know what size of paddocks Mr. Garland was considering and how many paddocks he would have for a year's grazing.

Mr. Garland : The size of paddock rather depends on the unit to which you can reduce the herds, the great point being to increase the intensity of control by reduction of the size of the herd as far as can possibly be done under each set of circumstances. It depends on the size of the village and the amount of grazing available. With regard to the best size of individual paddocks that is still undetermined. The indications are that 100 acres would be an absolute maximum, depending on the size of the herd. The object is again to keep control as much as possible and to provide sufficient area for grazing without trampling and selective feeding. As to numbers, somewhere about six paddocks seems suitable but all these things are still under experiment. There are just two other points mentioned. With regard to getting over this difficulty of fencing we have been experimenting ourselves with large paddocks of about 4 to 5 hundred acres with no fencing but merely marked off. I do not know the latest developments but we have found the use of rock salt a very useful means of controlling cattle from wandering, there must be water as well, which is often difficult to provide. Mr. Laurie says that burning definitely increases the coarse grasses ; we found that to be true in certain areas but to depend entirely on the grass types. If the more valuable fodder grasses are more mesophytic than the poor grasses, then the burn will do good and conversely.

Mr. Howard : I hope I am not wandering very far from the point but I would like to say that it seems to me that we are tackling the whole of this problem from the wrong end. It is all very well to try, as we ought to try, to improve our grazing grounds and to undertake research in order to provide better facilities for grazing, but it seems to me that all these are mere palliatives and no cure. The real problem in India is that there are too many cattle and it seems to me that we ought to say so. Although we must improve grazing grounds and do all the research on the subject we can, the real object should be to try to persuade the people to adopt stall feeding. Mr. Allah Bakhsh said that there are tremendous difficulties in the way of this : so there are, but the fact still remains that it can be carried out. Thus, in the eastern part of this province we had a really serious grazing problem. It was so bad that we had four different commissions to try to solve it for the concessionnaires and things become so difficult that the concessionnaires themselves realised that matters could not go on as they were, and during the last 10 years,—very slowly I admit,—there has been a tremendous reduction in the number of cattle grazed and the people have in fact taken up stall feeding. It does seem to me that, although we must go on improving grazing grounds, we should never lose sight of the fact that the real solution is gradually to persuade the people to drop this jungle grazing as far as they can.

Mr. Smythies : I would like to supplement the remarks made by Mr. Howard. The figures for the United Provinces are interesting. The total number of domestic animals in the province according to the last census was 42 millions. Of these, 41 million never come to our forests or near them, they are mostly stall fed or not fed at all. We have to deal with the odd million, and judging by the appearance of the cattle we find in our forests, they certainly seem to get less to feed on than the 41 millions that do not come to our forests. Taking the province as a whole it is evident that there must be a tremendous amount of stall feeding going on already and there is no real reason why stall feeding should not be increased in the areas where we have forest grazing. It is also a fact that free forest grazing makes villagers take no care of their cattle and do no stall feeding of any sort. In our Tarai and Bhabar Estates working plans it has been suggested that villagers should be given land free of land revenue and rent if they would grow fodder crops for their cattle thereon. But although there are enormous grazing areas in these forests (I think it is 3 quarters of a million acres) the fact that for four months of the year there is no grazing available presents serious difficulty, and it is just during those four months that the cattle owners could grow fodder crops on their lands and stall feed their cattle : if they were to do so, the difficulties would be very largely solved. There are two types of grazing land. There is a moist type such as we find in the Tarai and elsewhere which is not tree forest : in this type there is no problem at all, as the more the grazing the better the grazing. Where the natural vegetation is rank and the growth of grass is strong no limitation of grazing is necessary. The real problem, as probably in most parts of India, is in the dry tree type. In this type, all the experiments that have been carried out have given the same answer. To improve the grazing you must stop the grazing and that is really no solution. We have, as you saw two days ago and as you will see again on Sunday, experiments on a large scale in planting fodder species : we hope that these experiments will offer a solution of the grazing problem and will at the same time improve the condition of these forests. That is at present the only solution we have been able to get—growing fodder trees. We have started some technical experiments too and Mr. Mobbs will give us a few remarks about that.

Mr. Mobbs : We cannot say much about our experiment on grass production although the first of our *Leaflets* refers to this subject. The chief point that has emerged from this experiment which combines various conditions of protection, fencing, grass cutting and grazing is firstly that after you have protected your grass and got it to improve, if you let cattle get on to it unrestricted improvement is very soon stopped. We had one area that was protected for two years, and then opened to grazing for 6 months. After further protection for one rains it produced less grass than the second year's production. So since we have 41 million cattle and it is absolutely impossible to control the number of cattle that go into an area without undue expense in fencing, etc., I think that Mr. Howard's point of encouraging stall feeding is extremely important. We have found that protection which gives us a very large increase in the yield of grass when the time comes to cut it but once you admit cattle, that improvement is quickly lost.

Every year I have to write a report on the recommendations of the Agricultural Commission as to what the Forest Department has done to improve grazing. Since 96 per cent. of our cattle do not come to the forests at all, I think that we should also turn to the Agricultural Department and ask what they have done to encourage stall feeding ? And I would suggest that this conference should pass some resolution to say that the encouragement of stall feeding is not only the Forest Department's job.

With regard to the ecological aspect, I have also undertaken some detailed study of the grasses, and I think this conference might include a clause in its resolution suggesting that wherever grazing experiments are carried on. ecological and systematic study of the grasses should also be carried out. In our case it appears that when we have improved the grass, if we open it out to cattle even for a short period, they are so attracted to the nice grasses which are longer than they were before that they pull them up, roots and all, and the bad grasses consequently develop to a greater extent.

Mr. Shebbeare : I agree that the resolution should say that we feel that the Agricultural Department should also do some thing to encourage stall feeding. Actually the Forest Department in Bengal has already done something in this direction.

Mr. Homfray : The hill forests of Northern Bengal before about 1916 had nearly all been open to grazing. The Forest Department then started to encourage stall feeding and reserved in the forests a few very small exercise paddocks called *bathans*. This method has caught on extremely well and is working very satisfactorily. I have told one or two officers about *Napier grass,* which we have grown successfully in the plains. It was recommended by the agricultural farm at Dacca as one of the best fodder crops produced in the East. If we could sell it we should certainly cultivate it as a cover crop in *sal* plantations but as we cannot sell it the *sal* becomes suppressed. It wants a fair amount of rain, anything round 80″ to 100″ per annum. In Southern Bengal grazing is going on nearly everywhere and eventually we shall have to tackle the problem on the lines mentioned by Garland and Mobbs.

Mr. Osmaston : I am afraid we have not much to add for Bihar and Orissa. We have a comparatively large area of protected forests available for grazing and so far we have not troubled to introduce grazing closures. In Puri division we have started a rotational grazing scheme. In Palamau division a contractor has started a large grass farm where she grows her grass which she sends to Calcutta and other Military stations. But the interesting point is that the local people are getting very interested in the farm and I think are going to start stall feeding themselves if they can because they find this grass very good. All we can say in Bihar and Orissa is that we endorse the resolution that stall feeding should be encouraged as much as possible ; on the other hand I think it will be very difficult in very many parts of our province to induce the villagers to adopt it.

Mr. Ramiengar : This is not so serious a problem in Mysore at present as to affect our general forest work. It may be interesting to know the experience of Mysore in the regulation of grazing. The Government has a small Department for raising and maintaining a few special breeds of cattle. These cattle were originally intended for use in military transport, and so the management of the grazing grounds was vested till very recently in the Military Department. Since the last 10 years, this work has been delegated to a Live Stock Expert working under the administrative control of the Head of the Department for Agriculture. A sort of rotational grazing is being adopted by this Department by moving the cattle from one grazing ground to another so that after a short period of grazing lasting from about 2 to 6 weeks according to the extent of the land the area gets absolute rest for the rest of the year. The number of cattle is also limited to the extent of pasture land. The Forest Department is interested in these grazing grounds since the tree growth there is under its management and these areas are worked on a fairly systematic basis for extraction of sandalwood and firewood, the latter to meet the requirements of the neighbouring village population. The method of grazing adopted has, so far as observations go, not deteriorated the grazing while the forest growth also is sufficiently protected.

In the drier parts of the State, the Government have recently started a number of village forests managed by village communities. The primary object in the management of these forests is to provide adequate and good grazing to the village cattle and at the same time to raise a fair amount of tree growth consisting chiefly economic species. The progress so far achieved indicates that there is a good future for this class of forests and when this comes about, the incidence of grazing in the reserve forests would be considerably less.

To meet the current demand for grazing, a few experiments were made in small blocks of 1 to 5 acres in raising Rhodes grass in some of the forests of the drier tracts. Although the growth was satisfactory in the first instance, the introduced grass was checked by the more or less useless local spear grasses.

Another item of interest though not directly connected with grazing may be mentioned. In the Chitaldrug district where there is a compact block of about 18 square miles of pure *Hardwickia binata,* it was observed that owing to heavy grazing there was little or no regeneration of this species and this was entirely due to very heavy grazing. As an experimental measure about 6 square miles of this forest was enclosed with barbed wire fencing sufficiently strong to keep out cattle. There has been considerable improvement in the natural regeneration of *Hardwickia binata.* An abundant growth of grass has also come up in the area and is being cut and removed by the neighbouring villages.

In a few places where demand for grazing is appreciable, the Government have decided to give facilities in the way of water supply and are now budgeting a sum of Rs. 6,000 annually for effecting necessary improvements.

Mr. Deogun : Stall feeding should supplement forest grazing and not necessarily oust it. We cannot expect, especially in the hills, the villagers to fetch grass from long distances. They can only do so over short distances. The question becomes more difficult when we have to consider the rights and the privileges with which forests of a number of provinces are burdened. In this case the only solution is propaganda. The villagers should be induced to reserve all the near areas for grass cutting and the farthest for grazing. This may be made possible by starting demonstration areas as proposed.

In the case of professional graziers introduction of stall feeding can be accomplished with much less difficulty.

Experiments carried out in Australia, England, Japan, U. S. A., etc., all show the great advantages of conservative rotational grazing and whilst carrying out further experiments we should make an effort to introduce this rotational system of grazing whenever possible.

Mr. Hamid Yar Jang : We have not done any experiments as far as closures are concerned in Hyderabad.

Mr. Harnam Singh : The question of grazing in Kashmir is quite different from that in any province in British India in that grazing is not under Forest Control. It is further complicated by goat grazing which is a menace in that part of the country so far as forests are concerned.

It should be considered from two aspects, *i.e.,*—

(*i*) Improvements of pastures for local cattle and industries (wool and dairy). A very important one but not of a direct concern of the Department as at present.

(*ii*) Adverse effect of excessive grazing for if there is insufficient fodder for cattle it will tell ultimately on the forest growth particularly in the high level protective forests of birch and the low lying scrub forests where the goat graziers resort during summer and winter, respectively.

This excessive grazing by goats has a direct bearing upon another important question, *i.e.,* the erosion of the lower hills which is in progress. As has been pointed out in the discussions, reduction of animals is considered the best solution of these evils. The Kashmir Forest Department after over 25 years struggle succeeded in having a rising scale of fees for goats so as to ultimately eliminate them. It was enforced and began to show the desired effect. Unfortunately the measure had to be suspended for special circumstances and over 2 decades work done in that direction was spoiled. For a great portion of our coniferous forests, the question is not of any serious nature as goat grazing in deodar forests is prohibited, and under the grazing rules closures in forest under concentrated working can early be affected after fellings.

Mr. Deogun : The nomenclature of the subject requires standardising to avoid misunderstanding. I consider we should differentiate—

(1) ***Rotational grazing, i.e.,*** Restricted grazing of cattle rotating over units of the entire area,

(2) ***Continuous grazing, i.e.,*** unrestricted grazing of cattle over an area year after year,

(3) *Deferred grazing*, *i.e.*, grazing each portion of the grazing ground, in turn, the plants on one portion being allowed to mature their seed each year before the stock is admitted, and the stock being made to assist forage reproduction by trampling in the seed,

(4) *Periodic grazing*, grazing of cattle for a definite number of years followed by a closure.

Mr. Champion : I should like to state that for some little time all the information available has been sought from all sources with the object of compiling it so that those who are faced with the need of dealing these problems can make use of it. Mr. Deogun has been busy on this and he has, all the information collected in a draft on the subject. The discussion to-day should have led to some useful additions and opened up one or two further lines of investigation. As a research problem it is a very difficult one, and as Central Silviculturist I should not be at all anxious to produce a scheme for the Co-operative investigation of grazing and grass. Conditions vary so from place to place and the premises to which one is forced by local conditions spoil as a rule any scheme from the point of view of more or less acceptable research methods.

Mr. Mobbs suggested that we ought to pay more attention to the ecological side, that we should realise that grass is not merely grass but a very variable substance ; this is another of those practical difficulties which are very hard to overcome in practice—we are usually forced to classify the grass into rough groups of good grass, middle quality grass and more or less useless grass.

Mr. Smythies : In closing this debate it appears that the points which have been established are, first, the need for co-operation and co-operative work between the provinces, secondly the need for carrying out a systematic ecological study of grasses, and thirdly the desirability of reducing the amount to grazing in our forests, and of raising the amount of stall feeding.

ITEM 21.

Forests and Erosion.

No papers were submitted. There was a short debate in which the Inspector-General of Forests and representatives of most provinces took part.

The following resolution was proposed by Mr. C. G. Trevor, seconded by Mr. H. L. Wright (North-West Frontier Province) and passed by the Conference.

RESOLUTION ON ITEM 21.

Resolved that—

This Conference recognises that Governments realise the importance of this erosion question and have taken some steps to prevent the spread of erosion, e.g., the Punjab Government on Resolution 21 of the last Silvicultural Conference. The Conference would repeat that this question of erosion is of vital importance and urges that intensive propaganda should be started to educate public opinion.

Report of Silviculturist, Forest Research Institute, on action taken on the Resolution passed by the 1929 Conference.

The resolution called for the very serious attention of provincial Governments to the question of erosion and urged that if further proof of the seriousness of erosion losses were considered necessary, a proper investigation should be carried out. The Government of India brought the resolution to the notice of Local Governments for such action as they might consider necessary. The Punjab appointed an Erosion Committee in 1931 which issued a report in 1932. A forest officer was placed on special duty in 1934 to experiment on the control of torrents (*chos*) in Hoshiarpur district. Bengal reports that *Eupatorium* is now reclothing abandoned *jhums* very quickly and forming a good protective cover. Bihar and Orissa have been successful in leasing forests from private owners to prevent denudation.

Report of Debate.

(1) *October 29th.*

The President : I think we ought not to let this matter of erosion dangers drop. At least in the Punjab, members of the Legislative Council who are not actually inhabitants of the forest country have begun to take notice of forest matters. Thanks to a certain amount of propaganda, they have begun to realise that the destruction of the forest on the hills may jeopardise the canal water supplies on which they and thousands of other people live. And certainly in the Punjab the only way in which the public will be driven to interest themselves in these matters is when they find that their living is being jeopardised by diminishing canal supplies. I think when that moment arrives, the inhabitants of the hills will get very short shrift. There is a very active amount of interest being taken at the present moment in Hoshiarpur district. A special forest officer has been provided and I hope that if this matter receives continued stimulus, at last after 50 years of talk, something will be done. I think the Punjab in this respect is the worst province in India ; next perhaps comes Chota Nagpur which seems to be always either being washed away or blown away. Certainly when I was in Chota Nagpur I thought I had never seen more miserable land. I am not at all sure that in Chota Nagpur the Government of Bihar will not have to emulate Mr. Roosevelt and build a hundred-mile-wide shelter-belt across the country.

Mr. Villar : I think that probably in the far distant future owing to the silting up of the streams consequent on heavy erosion in the hills, much more may be heard of the destruction of unclassed forests. In spite of being well covered with forests we are doing quite a lot of reclamation of low-lying lands.

Mr. Howard : We are doing our best in the United Provinces. The local people there are interesting themselves in the matter at last and have even passed a resolution on the subject—but it has been a long struggle.

Mr. Laurie : Most of our geological formations in Madras are so old that erosion is not so conspicuous. There was a memorandum issued jointly by the Forest Department, the Agricultural Department, and the Irrigation Department, I think a couple of years ago. It was circulated to local Governments and to all interested and was then duly filed. I think everybody has forgotten all about it by now and no active action is being taken or appears to be necessary.

Mr. Champion : Might we ask the Punjab delegates (there are several of them) if they would draft a resolution confirming our 1929 resolution. I do not think we need a special committee for this but we should put it on record that this important matter was duly considered and that we were all agreed on it.

The President : I think Mr. Mohan might constitute his own committee and do the necessary work.

(2) *November 3rd.* (The debate was not reported *verbatim* : the following is a summary of what was said.)

Mr. Mohan : We propose the following draft resolution :—RESOLVED that this Conference recognises the steps taken by the Punjab Government on Resolution 21 of the last Silvicultural Conference but re-iterates its conviction that very serious attention of Provincial Governments should continue to be drawn to the question of erosion (especially in the catchment areas of the rivers) which is intimately bound up with the destruction of forests, incidence of grazing and lopping and suggests that intensive propaganda should be carried on to educate public opinion on the subject.

Mr. Allah Bakhsh recommended that each province should make investigations. In the Punjab an attempt was made in Hosiarpur, but the Deputy Commissioner did not accede apparently because it was thought that if the Department should succeed in one catchment they would want to take up others. This should not deter us ; we should ask again.

Mr. Garland said there was no serious erosion problem in Bombay.

Mr. Ramiengar said the same for Mysore.

Mr. Howard proposed that the Forest Department should urge Governments to take steps in the matter.

Mr. Osmaston said that in Bihar and Orissa, Government was afraid of cost. It has taken 10 years to start with a scheme to induce land owners to hand over lands to us for preservation of the forest. The Forest Officer makes working schemes. Bihar and Orissa is tackling problems for Chota Nagpur which is a large catchment area and local government do realize the need.

Mr. Trevor : We must recognise that some progress has been made in the matter, that Punjab has awakened and that Bihar and Orissa have done something in Chota Nagpur.

Mr. Ramiengar : Fixation of sand dunes endangering cultivation was taken up 50 years ago.

Mr. Harnam Singh : The question of erosion is of great importance to Kashmir next to Punjab and is directly correlated with heavy goat grazing in the Jammu Siwaliks. This heavy incidence of goat grazing as was pointed out yesterday on one hand clashes with grazing for sheep on the higher elevations and is responsible for deterioration of scrub forests in the lower hills, the latter is directly responsible for erosion in those localities. To reduce the number of goats the department succeeded in having a rising scale of fees in order to eliminate them but the project had to be later given up for political reasons.

If the attention of the State Government is invited to this serious problem it will have the desired effect.

Mr. Wright : In the case of Kashmir, goats have done a lot of damage so they were penalised by high taxation, but later on it was again reduced. This was done for increasing the ratio of sheep to goat, as sheep are more important for wool and are less destructive.

ITEM 22.

Preservation Plots and Protected Trees.

A paper was circulated by the Central Silviculturist summarising the action reported to have been taken in the several provinces on the recommendations of the 1929 Conference.

The subject was introduced by Mr. Champion with the salient features of his paper and comments on suggestions received on it, and Mr. Trevor also spoke. Pressure of time prevented further continuation of the debate but the attitude of the conference was one of general agreement.

The following resolution was proposed by Mr. H. G. Champion, seconded by Mr. C. G. Trevor and carried unanimously.

RESOLUTION ON ITEM 22.

Resolved that—

The Conference considers that a satisfactory beginning has been made in preserving as far as possible examples of our natural forests undisturbed by human interference. Further work on more systematic lines should be continued.

PAPER.

By H. G. Champion, *Silviculturist, Forest Research Institute.*

The resolution passed in March 1929 was as follows :—

Resolved that this conference recommends that, with the object of the preservation of the natural fauna and flora, necessary steps be taken to—

(1) Prepare lists of known individual trees or groups of exceptional interest, and preserve them for their natural lifetime.

(2) Direct local officers to recommend additions to the list as occasion arises. Exceptionally fine trees near roads and bungalows should particularly be considered.

(3) Preserve unworked in each province samples of adequate extent (ordinarily not less than 20 acres) of the chief types, virgin forest—including savannah—and natural regrowth receiving special attention. The areas should be as accessible as possible.

(4) Make available at the nearest Rest House information as to the whereabouts of such trees and reserves in the vicinity.

Further, that all such reserves should be demarcated as permanent Experimental Plots and placed under the Research Branch of the province concerned ; also that they should be listed in the working plans concerned.

In 1932, as it appeared that only two provinces had definitely taken action in the matter, a note was sent to the *Indian Forester* (February 1932, p. 109) with the idea that a broadcast reminder might help on the work. This drew a comment from Assam (*Indian Forester*, 1932, p. 287), and further reports from all provinces shewed that a good deal was being done ; a summary was published in *Indian Forester*, 1932, p. 387, and 1933, p. 112.

The reports and notes received in connection with the present conference may be summarised as follows :—

Assam.—Several proposals are still under examination though one plot of virgin *sal* forest in the Garo Hills has apparently been demarcated and its preservation prescribed.

Bengal.—A systematic survey of the existing types and sub-types of forest occurring in the province has been made, and 27 demarcated and recorded plots now exist. Some of them aim at the preservation of interesting very local species such as *Podocarpus neriifolia* and *Mesua ferrea* in North Bengal, but most of them are areas of about 20 acres representative of a forest type. In the Himalaya, the altitudinal range has similarly been covered systematically. Copies of the records have been received at the Forest Research Institute and Bengal has unquestionably done more to meet both letter and spirit of the resolution than any other province.

Bihar and Orissa.—No plots of the proposed type have yet been constituted but two *sal* sample plots of fine large trees have been preserved with their surrounds after their utility as sample plots had ceased with the felling for regeneration of the surrounding forest. Three other plots have been approved for preservation.

Bombay.—3 permanent plots have been selected including one of 608 acres in tropical wet evergreen and 20 acres in good moist teak. A few exceptional individual trees have similarly been preserved. No records have been received at the Forest Research Institute.

Burma.—Soon after the 1929 Conference, a 10-acre plot of good moist teak with *pyingado* was made in North Toungoo Division. No further action has been reported.

Central Provinces.—Five plots in *sal* forest of 5 to 65 acres, four plots each under an acre in teak, and one in sandal together with 50 single trees belonging to 16 species were listed in 1933 as being specially protected. No detailed records appear to exist.

Kashmir.—Groups and areas of forest of two different types are being set apart in accordance with the resolution. Temple groves protected by their own sanctity amply meet requirements for deodar.

N.-W. F. Province.—A plot of *Quercus semecarpifolia* has been laid out and 42 single trees of 5 species preserved.

Madras.—Two plots have been demarcated in the wet tropical evergreen in Palghat and Wynaad divisions and proposals are under consideration for three plots in temperate evergreen and teak forests.

Punjab.—Ten plots in different forest types and localities and 31 individual trees have been preserved. Records are believed to have been prepared but copies have not been sent to the Forest Research Institute.

United Provinces.—No list of the plots and trees preserved has been received at Dehra Dun. One or more plots of *sal, chir pine* and deodar have been demarcated and perhaps others.

Nomenclature and Classification.

Since the 1929 Conference the descriptive title *Preservation Plot* has found fairly general acceptance and might now well be defined and standardised, as a demarcated area set aside in perpetuity for the preservation of the forest with no human interference beyond what is necessary for its protection and maintenance.

It has been pointed out that in some plots we may be more interested in watching the natural succession than in preserving the existing trees as long as possible and that the form of protection and maintenance required will differ sometimes very fundamentally in the two cases. Thus root competition from natural regeneration under fine old trees might kill the latter, and for protection, preservation or destruction of regeneration or an underwood might be necessary if the object were to save the old trees (U. P.). Plots in which natural succession is the more important object might be called *ecological plots* (U. P.). This is taking the long view and is open to an objection that is frequently being put forward in that it adds to the variety of kinds of plot, to the confusion of all who deal with them. For this practical reason, I recommend that all these plots should be included under the one head *Preservation plots*; and where special measures are considered to be necessary to prevent natural succession endangering the primary object of the plot, such measures would be included under the prescribed treatment ; moderate grazing and burning might often be permitted or even prescribed. For the maintenance of a type, though I should not permit tree fellings under any circumstances, I would often cut climbers.

We have not yet arrived at a suitable term for single trees to be preserved similarly. I suggest " *Protected Trees* ".

The 1929 Conference suggested that lists of protected trees should be drawn up and posted in adjoining rest houses, and printed in working plans ; this does not appear to have been done anywhere so far. It also proposed that the Preservation Plots should be demanded and constituted permanent

Experimental Plots under the Research Branch to ensure their regular inspection, record and maintenance. This involves the filing of a copy of the record at the Forest Research Institute, and so far only Bengal has submitted such files. It is obvious that on the same grounds a copy of the list of protected trees should be with the Central Silviculturist.

It may be suggested that a section be added to p. 73 of the *Experimental Manual*, Vol. I, of the Silviculture Research Manual dealing with the subject. The following draft is put forward for consideration :—

I.—Preservation Plots.

1. *Number required.*—The series of plots should cover the range of forest types in a province both climax and seral.

2. *Location.*—Plots should be as accessible as possible.

3. *Size.*—The size of a plot may vary from about 1 acre upwards according to conditions, but should ordinarily not be less than 20 acres for a high forest type and preferably decidedly larger.

4. *Demarcation.*—The plot should be demarcated as a standard Experimental Plot, well defined boundaries such as rivers, ridges, cleared fire lines, or roads being preferable ; cut lines requiring repeated clearing should be avoided as far as possible.

5. *Initial Record.*—A file should be opened for each plot exactly as for a standard Experimental Plot with a situation map on Experimental Plot Form No. 1, and a description on Form No. 3. *Entry 1,* the object of the experiment, will be either :—

1. To preserve the existing forest as far as possible in its present form, or
2. To preserve the forest from all forms of injury and so permit the normal progression towards the climax form.

Entry 14.—Details of treatment to be applied would correspondingly vary with the plot, but, for example, might be :—

1. No fellings of any sort to be done ; the area will be open to grazing as hitherto, and will not be specially fire protected, but climbers will be cut wherever appearing to be likely to do significant damage to the timber trees.
2. No fellings of any sort will be done ; the plot will be fire protected by annual burning outwards from a cleared guide line.

Careful enumeration of the growing stock by species should be done, and a botanical survey would be valuable. A photograph from a recorded point so selected as likely to be suitable at later dates, would add greatly to the interest and value of the record.

Entry 15.—Intervals and season of inspection ; might aim at a minimum inspection interval of 5 years as for sample plots.

6. *Subsequent record.*—What should be recorded need not be laid down ; the plots will undoubtedly be used for collection of information on a variety of points, and if not, it only requires to be checked that the plot has been maintained as prescribed and that events affecting its condition and development have been duly recorded, on *Form 4 Subsequent history* which will be opened for each plot.

Note.—The list should be published in the working plan concerned.

6. *Numbering.*—A single series of arabic numerals for the province.

(Bihar & Orissa prefer divisional series, but the plots really are provincial.)

II.—Protected Trees.

1. *Demarcation.*—The trees for their protection require to be indicated without injury or disfigurement. An inscribed wooden board of resistant timber or timber treated with preservative may be nailed on without harm. Paint or coaltar bands or marks are disfigurements to be avoided.

2. *Initial Record.*—The trees should be allocated numbers in a single series for each division, all species together. Experimental Plot Form 3 should be opened for each tree but groups of trees could be dealt with on one form. The list for each division could conveniently be maintained in Experimental Plot Form 6*. Girth or diameter at a fixed height should be recorded and a photograph

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*C. P. has suggested special simplified forms.

3. *Subsequent Record.*—The girth or diameter should be remeasured at inspections not less than 1 year or more than 5 years' interval and any event affecting the growth or vigour of the tree recorded.

TE.—The list should be printed in the working plan concerned.

Note on Preservation Plots by E. C. MOBBS.

In the last Silvicultural Conference in 1929, the Central Silviculturist mentioned that "Nature Preserves" and similar areas have to be intelligently looked after. Since, however, the looking after has to be done not by one person for a long period of time, but by a succession of officers, each for a comparatively short period of time, it appears necessary to arrive at some general concensus of opinion as to what general principles the looking after shall follow.

In the first place, I think we should distinguish two distinct sets of plots—firstly, those in which we are preserving some particular trees, and secondly, those in which we are preserving a type of forest. In the first case, it is obvious that we must do whatever is necessary to preserve the existing trees as long as possible. This will involve climber cutting, removal of any dead trees from which insects or disease might spread, and everything that is involved in the term "protection". A point that perhaps might be overlooked is the question of root competition. In Garhwal division in the United Provinces we have a *chir* (*Pinus longifolia*) preservation plot, to save some fine old trees. They form a very open overwood, beneath which are patches of chir regeneration, now mostly in the tall sapling and pole stage, from 2 to 6 feet girth. It would be centuries almost before these trees would ever reach the size of the old trees being preserved, but in the meantime it appears quite feasible that the root competition of this developing regeneration might easily have an adverse effect on the older trees, two of which have actually died since the plot was laid out two years ago. Normally the big trees would be removed for the sake of the regeneration. Would the "looking after" of the big trees include the removal of the regeneration, and if so, what general principles should be followed?

In the second case, where we wish to preserve a type of forest, it is necessary to decide in the first place, whether we wish the type to remain as it is, with the present distribution of species, or whether we wish to study the progress of natural succession. From the scientific point of view, it would be very interesting to have a few plots which would be left to develop naturally. These might be termed "Ecological Plots", as distinct from Preservation Plots. In these I would suggest that only essential tending operations, such as climber cuttings and removal of dead trees be carried out, and if sufficient area is available, it would be interesting to have a small control area in which even these operations were not done. It would thus be useful to have some *sal* ecological plots, definitely protected and allowed to change to evergreen forest to see what is the ultimate climax. On the other hand, where it is desired to preserve a type of *sal* forest as such, the plot would be termed a preservation plot, and would not be given such strict protection as would involve a change of type, and the treatment might involve grazing and occasional burning or removal of miscellaneous species, together with thinnings among the principal species from time to time.

It is suggested, therefore, that we distinguish first of all ecological plots from preservation plots, and that we then divide the preservation plots into (*a*) those where we are preserving certain individual trees, and (*b*) those where we are preserving a forest type, and that for these three sorts of plots some general principles of management be laid down.

Report of Debate.

On the opening day of the Conference, the President made the following announcement :—

"With reference to this item, I should like to bring to your notice that this question was considered by a committee in London dealing with the preservation of the fauna and the flora in Africa, and it was suggested therein that what was called the strict nature of the preserve should be improved and that forest operations should not be carried into these preserves in which the flora should remain as it was and as nature intended it to be. This matter will come up again at a similar conference on the preservation of wild life which will be held in Delhi on the 28th of January next, which is being convened by the Government of India. In dealing with this item you will have to remember the desire of the international committee which assembled in London regarding having really good plots of virgin forests kept in perpetuity."

Mr. Champion : Opinion was unanimous at the last conference when we decided on a line of action which has been followed to a very considerable extent in the last five years. You will see from my summary that in all provinces,—including Kashmir which was the only Indian State represented—action has been taken. A good deal of initial work having been done, we shall be obliged further to consider a point which was brought up at the last conference but left for later consideration, that is the further maintenance of the plots. In particular, what work are we to do to ensure that these areas of forest that we have selected for preservation are as far as possible uninterfered with, and how are we to do it, and when should we do it ? I mentioned when I introduced this subject that other countries have met the same difficulty, and the position may be summed up to the effect that we cannot leave these preserves entirely to themselves. Some amount of care, possibly interference, is necessary. Attention has been drawn to the point that in fact there are two classes of forests in question, those which the ecologists would call seral stages or preclimaxes to the local climatic climax, and the actual climatic climaxes themselves. A climax type should be capable of looking after itself—that is implied in the definition of a climax type—but many of our forests at present are of the other class. Quite a lot of them have been to the climax and have been pushed back, particularly as regards undergrowth, directly or indirectly by human agency. Many of our forests which appear to be climax are not truly so and depend for their very existence on the annual burning which is directly or indirectly tied up with grazing. We shall then have to decide for our plots whether we wish to maintain them as they are, or whether we wish them to follow the natural course of events in future. We did think of this last time when we specifically mentioned the opportunities some of these plots would offer to study the natural succession. The suggestion from the U. P. is that it is necessary from the start to differentiate these two types, prescribe different treatments for them, and actually give them different names, restricting the term preservation plot to those which we wish to maintain in their present condition. It was pointed out that if we wish to maintain an area of forest with exceptionally fine trees on them, we might possibly have to take special steps since inaction is liable to be followed by the death of the old trees earlier than is unavoidable. I think there probably will be quite a number of cases where this is definitely a possibility and we shall have to prescribe a treatment which will retard progression. Ordinarily, this would simply mean that we would have to allow those influences to continue or come into play which have hitherto done this, for example, burning and grazing. On the other hand, if we want to follow natural progression, we shall have to exclude all possible forms of interference such as burning, grazing and all forms of fellings.

Should we cut heavy climbers on these plots or not ? If we are aiming at the preservation of particular trees including single trees such as the one we were shown yesterday (the *sal* tree dedicated to Professor Troup), the climbers must usually be cut. This will generally be found desirable, I think, in areas which have been selected as representing the finest growth of a particular species or dominant association. I am, therefore, of opinion that in the case of each individual plot it should be decided at the time the plot is laid out what the object in view is. We have already agreed that such plots should be constituted and we have agreed to include them among our research plots and there are special provisions on our standard record forms for noting down what particular treatment should be applied.

I am strongly of opinion that these plots are a provincial concern. The research officers are in the first place only the agents of the provinces in carrying out the necessary field work. Therefore, when the forest officers of a province decide that it is desirable to have such a plot in a given forest, suggestions are usually made as to where it can be found. The research officer may or may not be asked to select the plots but he will be asked to do the initial work of demarcation, etc. When this decision is reached, at the same time the same authority should decide what the object in view is, and in consultation with the research staff should also decide what the best treatment is to attain the object in view.

The question of nomenclature arises. We did not actually reach a decision at the last conference. But in the meantime the term *preservation plot* has crystallised out, and I do not think we can do any better. I should like to recommend that we accept that term for both the kinds of plots I have mentioned. Even though it is stretching the meaning of the word ' preservation ', the term is elastic enough to include both. Details of recording can, I think, safely be left to the research staff who have to maintain them. I do not, therefore, propose to make any further references to the details which are given at the end of my notes.

Before I leave the subject of preservation plots, I should like to draw attention to the very unequal action taken in the different provinces on the subject. The only province that has done anything really systematically is Bengal who definitely set out to see what forest types they have, which of them are worth preserving, and where suitable plots could be obtained. The developments elsewhere have been very unsystematic. Now, if this thing is to be done, it should be done properly and systematically with a very definite idea of what the ultimate object is, and I think the Bengal example is one to follow. The only other point that requires to be settled is whether one plot is enough for a province or whether a plot should be put in each tract or division. I think our immediate aim should be to have one good plot at least of each type. I think it is more than likely that in the course of time these plots will be appreciated as in Europe, and there will be a demand for plots at least of the more outstanding types in more than one locality. It is obvious that the object served is somewhat different in the two cases. Perhaps the aesthetic side is more important than the scientific in most countries ; the aesthetic side has been developed with the passage of time and this will probably happen in India too. So let us have a scheme covering the ground and leave the rest to natural development.

Turning now to Protected Trees—I recommend this term for general use—I would like to emphasise the importance of avoiding all disfigurement of the trees which we wish to preserve. If label there must be, let us see that it is not too conspicuous. Obviously some form of demarcation has to be done. If it is too inconspicuous on the ground to those working in the forest, damage will be done. It seems to me that it ought to be possible to devise means of attaining both objectives satisfactorily. I have seen examples in the Central Provinces where an officer had selected quite a large number of fine trees for preservation, a very satisfactory step, but most of them had been disfigured by large coal-tar bands and numbers printed on them. Support to my proposals was general last time, and I am confident that I shall find the same support for a resolution in some such terms as the draft I put before you.

Mr. Trevor : All I have to do is to tell you that this subject is sure to be brought up at a conference which is being convened by the Government of India in Delhi on the 28th of January to discuss the preservation of wild life, and if I am asked to speak on the subject, I shall inform the conference that this matter has been in the hands of the Forest Department for the last 10 years and that a beginning has been made. At the same time I would ask all of you on return to your provinces to see that this question is really properly attended to. Recently I was on tour in Madras quite near an accessible rest house and I went through a most beautiful area of tropical rain forest, the first I had had the opportunity of seeing, and I hoped to find it had been made a preservation plot. But I was given to understand that it was not a preservation plot, but that it was included in the working plan, and all the finest trees carried large black numbers which did not improve the appearance of the forest. Now that was an ideal place to make a preservation plot. It was of very little monetary value and it was one of the few easily accessible places in India where a forest officer can go out in the evening and see a tropical rain forest. I think we ought to do considerably more in this line, otherwise we shall be accused by our successors of being Vandals and of having done nothing to preserve the forests Nature gave us when we first took over charge. I hope considerably more attention will be paid to this question in the future than has been in the past.

Mr. Smythies : I should like to add a note. We have got a game sanctuary of 120 sq. miles already in being, and it is going to be converted into a National Park. Inside that we have 100 acres of forest which may not be felled over and is to be one of the preservation plots. So there we shall have the combination of the preservation of game and the natural flora.

Mr. Champion : I consider that an ideal arrangement.

ITEM 23.

Mixture of Species in Plantations.

Notes were received from Bengal, Madras, Assam, Bombay and the Punjab (see below). The debate was opened by Mr. C. K. Homfray (Bengal) and after an interesting debate in which the leading part was taken by Mr. Smythies, who described recent developments with mixed lines in the United Provinces, and Messrs. Laurie, Howard and Trevor, the following resolution was proposed by Mr. C. K. Homfray, seconded by Mr. Purkayastha (Assam) and passed by the Conference.

RESOLUTION ON ITEM 23.

Resolved that—

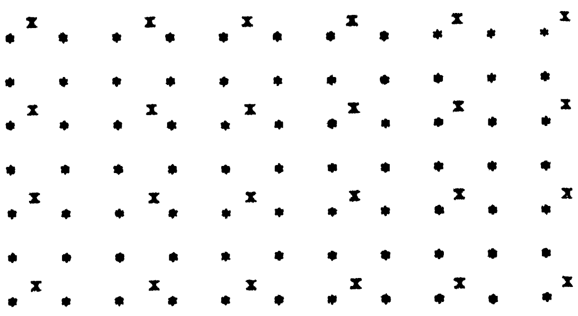
This Conference recognises the importance of raising mixtures in plantations and is of the opinion that it may be undesirable to raise pure plantations of species that do not grow pure in nature. Experiments should be carried out to this effect.

Sporadic attempts with experiments have been made in the past, but have usually failed owing to the lack of knowledge of the silviculture of the species concerned. It is therefore suggested that the Central Silviculturist should issue a bulletin dealing with the subject, on the lines of Bulletin No. 78 of 1932 (Problems of teak plantations), giving past work and experience in India, and also giving the different methods in vogue in Europe and other countries with suggestions for their application to Indian conditions.

(*i*) *Madras.*—There are no new developments to report. The mixture, (so-called), of teak and mahogany on poor laterite areas in teak plantations at Nilambur formed forty years ago by planting mahogany trees spaced 50 feet by 50 feet in the teak plantations has resulted in these mahogany trees taking charge and forming immense branchy crowns suppressing all the teak and other species round them. Mahogany is obviously not a suitable species for an intimate mixture with teak on such areas as it grows so much faster and suppresses it badly.

At Mount Stuart attempts to grow rosewood in mixture with teak in strips of varying widths were a failure. The rosewood was badly browsed from the start, and attempts to preserve it by allowing the weeds to cover it up soon led to its almost complete extermination. The effect of these strips on the teak was also very bad. Not only were large persistent side branches formed early in the life of the plantation but the rosewood strips proved to be a source of infection for climbers and weeds which spread into the teak strips and necessitated expensive cleanings. It appears necessary for the successful establishment of a mixture by alternate strips that the species used should grow at approximately the same rate. (Strips were 1 to 30 plants wide—*H. G. C.*).

More hopeful results have been obtained by the method started by Mr. T. A. Whitehead of sowing rosewood seed at the same stake when making teak plantations. The operation only costs about Re. 1-12-0 per acre extra and the rosewood plants get tended along with the teak without any extra cost. Much of the rosewood disappears,—probably about 60 to 75 per cent. of it, but what remains grows fairly happily along with the teak and after three years may be from a quarter to more than half the height of the teak. The idea is that one should be able to favour the rosewood and regulate the mixture as one likes at the time of thinning. *Pterocarpus marsupium* has also been introduced in the same way but the results are not so hopeful. It has been suggested that a better way of introducing rosewood would be to plant stumps in quincunx—in between alternate rows, *i.e.*, 1 rosewood stump to 4 teak stumps. The advantage would be a much more even distribution of the rosewood. It



* = teak plant. x = rosewood plant.

might be a little more trouble in staking and tending, and would cost slightly more but it would be much more certain in results as the rosewood would compete less with the teak both above and below ground, and would still get overhead light at the time when most of it disappears, namely the third to fourth year. Stumping is also more reliable and gives faster growth of rosewood from the start.

It is noticeable that the rosewood raised in intimate mixture with teak by sowing at the same stake does not suffer from browsing appreciably. Whether this comparative immunity would also be enjoyed by rosewood planted in quincunx in the open between the rows of teak remains to be seen.

Attempts to raise mixtures of teak and *Artocarpus hirsuta* at Mount Stuart were made for a number of years but were all unsuccessful, the *Artocarpus* dying out in the hot weather. Similar attempts were made at Kannoth where success was attained in one corner of a compartment over a small area in an old plantation (1877). Both species occupy the top storey but the *Artocarpus* has developed larger crowns than the teak and has a greater girth. The crowns of the *Artocarpus* are mostly just below the teak crowns and the mixture is evidently a suitable one. The difficulty is usually in getting the *Artocarpus* established. It appears to require a certain amount of shade in the hot weather when young which the teak does not give it, and only in a very humid climate like Kannoth has it been successful, and even there only over a portion of the area planted.—*M. V. Laurie.*

(*ii*) *Assam.*—In certain places where mixture of *Terminalia myriocarpa* and *Lagerstroemia flos-reginae* were tried in alternate lines, the mixture has ultimately ended in a pure crop of *Terminalia myriocarpa* which is more fast growing than *Lagerstroemia flos-reginae* in the early stage. Mixture of *Lagerstroemia flos-reginae* with *Mesua ferrea* as an underwood promises to be a success—the latter being a dense shade bearer, but sufficient experience has yet to be gained before coming to any final conclusion.—*C. Purkayastha.*

(*iii*) *Bombay.*—Attempts to find suitable species for mixture with teak in plantations have been abandoned, as none of those tried have proved satisfactory. Attention is now concentrated on adjusting cleaning and thinning technique so as to obtain a sufficient under-storey of species which regenerate themselves naturally. In other words no attempt is now made in the plantations to obtain any money-crop except teak. The subsidiary species are encouraged simply for their value in soil protection and improvement and are always sacrificed if they threaten to interfere with the growth of the teak.

A pair of sample plots have been laid out for the study of relative increment of a teak plantation kept absolutely pure as compared with one in which a natural under-storey of other species (in this case *Xylia xylocarpa*) has been kept.—*E. A. Garland.*

(*iv*) *Punjab.*—In the irrigated plantations of the *Punjab*, mixtures of *shisham* (*Dalbergia sissoo*) with mulberry and *Eucalyptus* species have been tried on a large scale. At Chichawatni in 1929-30, mulberry and *shisham* stumps (root and shoot cuttings) were put out in alternate trenches as well as in alternate patches over a large area. Some of the mulberry cuttings died but were replaced, and the whole area was well irrigated. Although 60 per cent. success was obtained at the close of the irrigation season, a very large number of mulberry cuttings were killed by frost during January 1930. This time the failures were replaced by *shisham* cuttings and the number of mulberry survivors are so few that the crop can hardly be called a real mixture of the two species. A second attempt during 1932-33 having similarly failed, the idea of growing these species in the open has been given up.

The mulberry however is introducing itself naturally, through seed carried by water or disseminated by birds, under *shisham* trees thus forming an understorey, which forms a mixture of great value, economically and ecologically, in the second rotation. Where the natural spread is slow or deficient, the mulberry is being introduced artificially. Experiments carried out at Khanewal have shown that direct sowings of mulberry in lines or patches along the berm of trenches do not succeed while stump planting under a thinned *shisham* crop is very successful and is now the usual method adopted. The cuttings sprout under the heaviest shade but the growth remains restricted. Best results have been obtained by introducing mulberry in 1 to 3 year old *shisham* or *farash* (*Tamarix articulata*) crops.

Mixture with *Eucalyptus rostrata* has mostly been tried at Changa Manga. It is grown in bottomless pots, carried to the site and planted entire. In one compartment *Eucalyptus* was planted 15′ apart with 3 *shisham* cuttings in between and mulberry has come up naturally. The two latter species, *shisham* and mulberry, form the lower storey. Although the *Eucalyptus* are 15′ apart, the *shisham* does not stand even this much shade and is not putting on good growth. A thinning has now been carried out to space the *Eucalyptus* 30′ apart and what effect this will have on the under-storey remains to be seen.

The *Eucalyptus* have also been planted 5′, 8′ and 10′ apart. *Shisham* in such areas is rare and the under-storey of mulberry has suffered only under the closely spaced *Eucalyptus*, 5′ apart.

As *Eucalyptus* plants require constant weeding and are much damaged by white ants, their cultivation has not been extended to other plantations, particularly as their economic utility has not yet been determined.—*Pratap Singh.*

Note written for the Silviculturist, Bengal, by the Silviculturist, Forest Research Institute.

The feeling against pure plantations has originated in Europe primarily on the instances of pure spruce and pure oak. Most of the pure spruce has been raised by planting on clear fellings or old fields, etc., and there are unquestionably a series of contributory factors at least partly accounting for recorded unsatisfactory development. For example, spruce was not the species occurring naturally, often not even indigenous, seed of unsuitable strain was often used, afforestation of old fields and pastures nearly always gives difficulties whatever species or mixture is used, and so on. Excellent natural pure spruce forests exist and regenerate well to spruce. Moreover, results with spruce with its exceptionally flat rooting system and heavy slowly decaying humus building habit, are not safely extended to other species. Oak is the stock example of the pronounced light demander requiring an under-storey or admixture of a soil improving species and clear instances undoubtely occur where the introduction of beech has worked favourably in all respects. It has however also been shewn that this good effect is not universal, but that under different soil and climatic conditions, the introduction of beech can react unfavourably on the oak.

In warmer countries, the example of teak is quoted, but the few clear cases of deterioration in pure crops appear quite possibly ascribable to details of treatment which can be corrected and extensive experiments with mixtures in Java have failed to reveal any advantage whatsoever to the teak. For *sal* there are perhaps indications that regeneration may be facilitated by an admixture of other species, but none that the growth of the *sal* is helped. With other species, we have instances where pure plantations have started well and then fallen off or even been lost from insects or quadrupeds, from fungi or uncertain physiological causes, and it is really these instances which necessitate closer study of the raising of mixtures. There is, in addition, a call for the combination of quick growing softwoods which can be grown on a short rotation with more valuable but slower timber species which might be met better by raising mixed plantations than pure ones.

Past experience in India.—This is largely a record of failure
few instances may make a good showing. The two chief causes of
they have been so influential that it is hardly necessary to loo
been :—

(*i*) Lack of adequate knowledge of the silviculture of the spe

(*ii*) Lack of continuity of treatment after the initial stages.

As a rule one of the species tried in experimental mixtures has been one long and extensively used, so that raising it in plantation is a routine matter and successful, whilst the others have been species previously not or very little used, or only tried on a small scale ; consequently, failure is not surprising. Commonly, too, the ground suitable for the well-known species is recognised, but not that for its intended associates.

Immediately a mixture is established on the ground, questions of tending arise and a clear cut policy must be decided on from the earliest stages dealing with such points as the proportions of the species desired in the final crop, whether a species is to be specially freed to keep it in the upper canopy, whether mixture by groups or single trees is required and so on. Otherwise vigorous stems of a possibly less valuable species get cut to free less vigorous ones of another species and often later on the latter in turn are cut as of poor quality and competing with promising stems of the former.

It is therefore a *sine-qua-non* for raising mixed plantation on any but the smallest experimental scale, that we must be able to guarantee good stocking from the start with all species used, and we must know their approximate rates of growth in the all important early years. Later development in height will often not proceed exactly according to prediction from development in pure plantation, but a fair knowledge of natural cleaning and shade enduring power is also essential.

The practice of sowing or planting a mixture of a number of species without prior knowledge of their artificial regeneration in the hope that something will grow is thoroughly unscientific and if it is sometimes successful, no credit is due. Again, in a general way, experience with two species mixtures should ordinarily precede experiments with 3 or more species mixtures, though sometimes these need be no more complicated as in the methods to be described.

It has also to be realised that even in two-storeyed high forest, one does not grow two trees in the place of one and that too much cannot be expected and certainly will not be obtained, from the lower storey if the upper is maintained as it would be in a pure crop.

METHODS OF MIXTURE IN PLANTATIONS.

A. *Two species mixtures*.—(Patch sowings may be read for plants throughout.)

(1) *Mixed line sowings*.—Satisfactory results appear to have sometimes been attained where the major species has got well away and the secondary has filled up gaps where the former cannot grow well, or has remained more or less below the main canopy. Where both species have started fairly well, any trouble encountered has usually been due to vacillating policy in thinning or to failed attempts to hold back the more vigorous species for the benefit of the less vigorous. Given a definite policy to encourage species 2 in definite groups where it is doing well and can (at least with little help) hold its own against species 1, the method is a promising one, combining the advantages of both pure and mixed plantations and more fully utilising the locality. Where 2 is definitely slower than 1, it is only possible to retain it, if it is at least a ½ shade bearer and it can only form a lower storey to 1 : attempts to draw it up must be expected to fail. Where even growth is obtained and thinnings are consistently done on stem and crown form regardless of species (except in cases of uncertainty when a specified species would be favoured) a satisfactory mixture may result. Optimum proportions in the mixed seed can only be determined by experiment and results with a given mixture will probably vary with density of showing, year and soil. As a rule sowings should not be very dense.

(2) *Alternate plants*.—This is the same as method (3) except for spacing whether the species are ' stepped ' in adjoining lines or not. If the species are used in unequal proportions, similarly, method 4 results, and if one species greatly predominates, similarity to method (6) is reached.

2 1 2 1 2 1 2
1 2 1 2 1 2 1

(3) *Alternate lines*.—Past experience has shewn that success is exceptional except where species 1 is a faster growing major species, 2 being a minor species subordinate to 1 and becoming topped by it to a varying extent. Failures are mostly the result of the suppression of one species beyond recovery before first thinning or are ascribable to vacillating thinning policy favouring now one now the other species.

2 2 2 2 2 2
1 1 1 1 1 1
2 2 2 2 2 2

Unless species 2 is a fairly good shade bearer it will soon be suppressed and lost ; if it is good shade bearer, it may ultimately form a satisfactory second storey but it usually more or less drops out in the dense young pole stage of 1, no reasonable heaviness of thinning serving to retain it. Species 1 is thinned virtually regardless of 2 which tends to be thinned naturally by suppression except where there is a gap in the canopy. Rather closer spacing may be advisable if required to keep 1 clean.

It is possible that with species 1 and 2 both light demanders of not very different rate of growth, better results might be obtained were it the prescribed policy to differentiate more or less pure groups in the course of thinning. Where the rather slower growing species appeared to be at its strongest, the thinning would concentrate on the other and so release pure groups where they were most likely to hold their own. On this method the edges of the groups are least likely to give trouble. Continuity of treatment would be a *sine-qua-non* to success. This method tends to lead to an irregular form of methods (5) or (6), q. v.

(4) *Alternate groups of lines* (*strips*).—2|111|222|111|2 . . .—The object here is to check the tendency of the quicker growing species to suppress the slower. The central parts of each strip grow up evenly as in a pure plantation and at least a central line should survive to the final crop. The marginal lines can be left to fight it out, the thinnings along them aiming at keeping the best shaped stems of either species but always subordinating them to the good of the central lines. The number of lines in a strip may be varied within wide limits depending on the species in question and the desired proportions in the later stages of growth. If there is an even moderately marked difference in rate of growth, it must be accepted that the edge trees of the quick strips will be of bad shape and will spread over and more or less suppress the edges of the slow strips with resultant loss in clean timber volume and quite likely in total volume also. The method cannot be recommended under these conditions unless 1 is a shade bearer and definitely slower than 2, when it may be represented by fewer lines and the function of under-storey definitely allotted to it. Thus there might be 6—10 lines of 2 alternating with 2-3 of 1.

(5) *Alternate plots.*—The plots might be of varying size but probably not less than 5 × 5 plants nor more than 10 × 10 so as to give a fairly intimate mixture at the end. The underlying idea is much as in (4) to give the final yield trees the uniformity of environment which leads to the formation of straight clean timber and the same considerations would apply to the thinnings. A diagram will however shew twice as great a length of margin as for the strips and the only counteracting advantage is the avoidance of the continuity of the strips unfavourable with exposure to some forms of injury. The proportion of the species may be varied by having two or three diagonal rows of plots of 2 to one of 1.

1 2 1 2 1 2
2 1 2 1 2 1
1 2 1 2 1 2

On the whole, the method seems to possess no real advantage over (4) and is not so simple and it is only recommended where experience has shewn that strips are dangerous.

(6) *Single plots.*—Plots of species 2 of selected size and frequency introduced in an otherwise pure crop of 1. The plots of 2 may be of any size from 5 × 5 plants up to 20 × 20 after which pure crop conditions would prevail, and similarly they would not be separated by more than 5 to 20 plants of 1. Three possibilities occur according as to the growth of species 2 =,>, or < than that of 1. If 2 is definitely slower than 1, it must be at least a ½ shade bearer and should be less valuable, in fact the method chiefly commends itself for introducing a soil improving species which may spread under the canopy of 1. With approximate equality in growth the method is a good one for introducing a proportion of a second species under conditions which encourage natural cleaning. If 2 grows faster than 1, there is the disadvantage of a large periphery to reduce which the groups should be larger. The extreme case of single plants of a second species, possibly specially favoured all their life, can only be considered with a very complete knowledge of the development of both species.

1 2 1 2
1 1 1 1
1 2 1 2
1 1 1 1

B. *Mixtures of more than two species.*

It may be taken that at least one species is a shade or at least a ½ shade bearer not intended to occupy any significant part of the main canopy.

(7) *Mixed line sowings of several species.*—No new point arises beyond method (1). If species 1 definitely exceeds the others in importance, thinnings may be done entirely to its benefit, leaving 2, 3 to occupy chance gaps and form an underwood, but ordinarily the treatment described under method (1) would be followed, and groups of species 2 or 3 kept where they shewed clear signs of promise, less satisfactory trees of species 1 being removed in their favour : this policy would have to be laid down and adhered to. Any species intended as underwood should be specified as such and others not removed to get it up.

(8) *Alternating plants of several species.*—Proportions can be varied at will with due consideration to known relative rates of growth. Further considerations are exactly as for (9), *q. v.* The lay-out is rather too complicated for most taungyas.

1 2 3 2 1 2 3 2 1 2 3, etc.
3 2 1 2 3 2 1 2 3 2 1

(9) *Alternating lines of several species*—Very varied arrangements are possible. the ordinary case being probably (*b*) with 50 per cent. of one species and 50 per cent. distributed among the remainder The latter may be various light demanders and the former a shadebearer to form an under-storey, or the 50 per cent. may be a quick growing light demander, perhaps to be removed early, and the rest slower timber trees to take their place in time.

(a) 1 2 3 2 1 2 3
1 2 3 2 1 2 3
(b) 2 1 3 1 2 1 3, etc.
2 1 3 1 2 1 3

(10) *Alternating groups of lines of several species.*—The same considerations apply as to the 2 species mixture. and the intention would be to vary either the ultimate dominant, or less often the under-storey. The method appears promising for the former purpose as the two or more species are helped to same extent from too severe competition in the early stages if they are grown in separate strips.

(11) *Alternate plots of several species*—The point is again the creation of mixture in the ultimate upper canopy and would in practice be by single trees or quite small groups of 3—5 trees dominating and filled out by a lower secondary species. There appears to be no advantage over method (10) which is simpler except where pure strips are particularly liable to be damaged.

1 2 1 3 1 2 1 3
2 1 3 1 2 1 3 1
1 3 1 2 1, 3 1 2

(12) *Single plots of several species.*—This amounts to groups of two or more species scattered in a plantation primarily of one species. The groups must be able to take care of themselves as they have a large periphery and would be of trees definitely unsuited for growth in extensive pure crop, or species exposed to risks necessitating scattering. Single trees are rarely advisable and large groups give pure plantation conditions.

Choice of method. [L. D. = light-demander ; S. B. = shade bearer.]

A. *L. D. with S. B.*—Mixed line sowings are possible, but competition is usually so severe, that the S. B will often be lost unless definitely aided in the thinnings and nothing more than a thin irregularly scattered underwood will result unless the L. D. is kept fairly heavily thinned in the first 2 or 3 decades. Alternate lines are more promising but in many instances not altogether satisfactory. If the L. D. develops rapidly and cleans itself well, enough of the S. B. should survive to give a fair under-storey, but with many species it is necessary to reduce the space between the lines to ensure good stem form and the S. B. lines suffer accordingly. Alternate groups of lines with wider strips of the L. D. than the S B appear promising, alternate plots less so. Single plots of L. D. among S. B. have much to recommend them where a good saleable S. B. is available whilst the converse case of single plots of S. B. among the L. D. is probably the best way of introducing a soil improving underwood, the plots being large enough to ensure good development and natural spread taking place later on as the L. D. crop opens up.

B. *Two light-demanders.*—Mixed line sowings will usually result in the early dominance of the quicker species, but provided the difference in rate of growth is not too great, very early thinning freeing the desired proportion of the slower one, may remedy this. Not rarely, however, it will be found impossible to maintain an intimate mixture in this way and sound silviculture will only favour groups of the slower species where there are good indications that it will respond and hold its own. Alternate lines present the same problems with the same suggested solution. In both methods, marked difference in the rate of growth can only result in the complete domination of the area by the quicker species. Alternate groups of lines will give the slower species a better chance and provided the strips are wide enough the final crops should include well grown trees of both species in proportions dependent on their crown form and the relative width of the strips. Too marked a difference in rate of growth will be worse in its consequences than with the previous methods considered, the marginal trees of the quicker species spreading far over the intervening strips. With the usual 6′ spacing between lines and a final crop of 120—150 trees per acre, three lines would drop more or less to one, and it would be probably better to start with rather more lines say not less than 5 ; it would also usually be preferred to have more of one species and this would be more safely done by increasing the number of lines than favouring it in thinning at the junctions. Without substantial reasons for expecting fairly equal growth to a height of 20 feet or so, the method cannot be recommended.

Alternate plots only offer the possible advantage of rather more intimate mixture and should not be attempted except with species known to develop fairly equally.

Single plots mechanically distributed have no advantage over strips unless they are wider and so have less periphery per unit area. If a relatively small proportion of a second species is desired, this is probably the best method of introduction. The real advantage of the method lies in the possibility of selecting patches of soil less suited to the chief species. Shape is of no importance though the periphery should not be unduly long. Size might vary from 50 trees to 100 or more but beyond about 150 pure crop conditions would arise, just as they would for the chief species if the groups are only few and far between. This selection of soil calls for experience but often gets over the difficulty of inequality of height growth.

C. *Two shade bearers.*—The same considerations hold as for B, but are less influential owing to the greater resistance of S. B.'s.

D. *Two or more L. D.'s with 1 S. B.*—This mixture in its practical aspect as in its theoretical is a direct combination of A and B. Tending of mixed line sowings will accordingly be very difficult and alternate plants on lines likewise, the most likely line mixture being alternate lines of the S. B., the L. D. being grouped in threes to eights. Plots of L. D.'s with the S. B. in alternate lines throughout might be worth trial as rather less likely to give trouble at the junctions than alternate plots of the 2 L. D.'s only. As a variant, the L. D.'s might be separated by 1 or 2 of the S. B. leading on to the single plot method which has a good deal to recommend it, the L. D.'s constituting the plots in a matrix of S. B. provided the latter is a species of some value.

2	2	2	3	3	3
1	1	1	1	1	1
1	1	1	1	1	1
2	2	2	3	3	3
1	1	1	1	1	1

E. *Two or more S. B.'s with 1 L. D.*—Here the L. D. would probably be intended to give an early return and the S. B.'s to carry on as the final crop. As single L. D. trees so rarely develop satisfactorily, it would be best to distribute them in small groups through the mixture of S. B.'s which as seen above would probably best be raised on the groups of lines methods with relatively few lines in a group.

Age difference.—Accepting the position that regeneration work must be completed in 2 or 3 seasons, considerable help may be given to a species in a mixture by earlier sowing or planting or by the use of larger transplants. The usual suggestion is to introduce the more slowly growing species first to get it well established before it is shaded by or has to complete with the quicker growing and this procedure can be recommended. The opposite procedure has been suggested for S. B. + L. D. mixture with a marked difference in growth, on the ground that the L. D. gets up quickly and a higher canopy is less harmful to the S. B. than a low one : it would appear that this could only be applicable with such an exceptionally quick and light species such as *Alnus.*

Examples suggested by Bengal officers.

Shorea and *Cedrela.*
Shorea and *Michelia* (1).
Michelia and *Chickrasia.*
    Bischofia (2).
    Amoora.
    Cedrela.
    Chickrassia with
    Duabanga and
    Terminalia myriocarpa (3).

Gmelina and *Cedrela.*
    Lagerstroemia.
Alnus and *Michelia* (4).
    Quercus spp.
    Castanopsis.
    Machilus spp.
    Bucklandia (5).
    Cryptomeria.

Item

Cinnamomum and *Bischofia.*
Cecidodaphne.

Acrocarpus and *Cedrela.*
„ *Chickrassia.*

Terminalia and *Chickrassia.*
myriocarpa *Cedrela.*
Polyalthia.

Cedrela and *Lagerstroemia.*
„ *Swietenia.*
Lagerstroemia with
Bischofia.

Chickrassia and *Swietenia*
Lagerstroemia and *Bischofia*
Bombax and *Cedrela.*
Dalbergia and *Cedrela* (6)
and *Anthocephalus.*

Cryptomeria **and** ***Bucklandia.***
Michelia.

Michelia and *Bucklandia.*

Notes.

(1) Unsatisfactory when single trees planted in gaps in *sal* lines.

(2) Not satisfactory (C. K. H.).

(3) A good result at Samsingh, the *champ* being a bit behind but healthy at 12 years.

(4) Looks promising up to 4-5 years (C. K. H.).

(5) Good at Batasi.

(6) Fair at Rehti at 3 years.

Selections recommended by Central Silviculturist for trial.

Shorea.—I do not consider admixture necessary provided the *sal* is definitely restricted to ground fully suited to it. At least two other species should be in regular use on ground too wet or too badly drained for it, approximating method (12) but nearer small pure crops. The probable need for burning in *sal* to keep conditions in the preclimax state rules out mixture with firetender species such as *champ.*

Michelia.—This is suffering severely from *Urostylis* in the pure plantations but mixture is not likely to make a great difference. *Michelia* is exceptional in its habit of straight growth with relatively clean bole even when standing free and so is very suited for use in mixture. *Cedrela* and *Chickrasia* appear the most promising companions whilst *Bischofia* and *Amoora* have been suggested as good shadebearers to go with it. Experiments might be made on method 4 with groups of lines of *Cedrela* or *Chickrassia,* and on Method 6 with groups of *Michelia* among *Cedrela.* Method 7 with groups of *Michelia* among mixed line sowings of *Chickrassia* and *Terminalia* might be repeated as also Method 3 with alternate rather widely spaced lines of *Bischofia* or *Amoora* (or Method 9 using both).

Terminalia myriocarpa.—The mixed line sowings with *Chickrassia* should be repeated trying varying proportions of seed and prescribing aims in cleaning. *Cedrela* might be similarly used. *Polyalthia* should be tried on Methods 3 and 6 after a Stage 1 trial for regeneration technique. Other suitable evergreens should also be similarly tried.

Lagerstroemia flos-reginae.—The same admixture and methods as for the last species. Given suitable soil conditions, Method 10 might be considered for these two species with *Cedrela* or *Chickrassia* as semi-shade bearer, or *Polyalthia* or *Bischofia* as shade bearer.

Cedrela.—With the proportion of *Bombax* very low but maintained if necessary in thinning, this is a mixture worth trial on Method 1 or Method 3, the *Bombax* line also having a considerable proportion of *Cedrela.* An admixture of *Acrocarpus* on the same lines is a possibility, or Method 6 could be tried.

Dalbergia.—Methods 1, 3 and 6 with *Cedrela*, the *Dalbergia* predominating. If *Albizzia* is looked on as having any future, it could be tried under the same methods, and together with *Cedrela* under Methods 7, 10 and 12. Ditto *Holoptelea*, another natural associate of *sissoo.*

Gmelina.—This appears a difficult species to mix with others, but to require some admixture after the early stages. Methods 4 and 6 alone appear likely to succeed and should be tried with *Cedrela* in strips of not less than 6 lines. Under Method 6 the plots might be of *Gmelina. Lagerstroemia* has also been suggested for trial and could be experimented with under the same methods. *Albizzia* is another possibility. No shadebearer has been suggested but should be looked for for trial under method 4, as 3 is unlikely of success without inacceptably wide spacing.

Alnus.—With its exceptionally fast and straight growth and light canopy, it is an excellent species as an overwood, and offers the best prospect of successful combination of a short rotation overwood combined with a long rotation second species. Method 3 looks most promising but method 5 with groups of 2 or 3 lines is worth consideration as also 1 line of alder to two of the associate.

Michelia excelsa.—The mixture with *Bucklandia* is suggested. Only methods (4) and (6) appear likely to develop satisfactorily.

Report of debate.

Mr. Homfray.—Notes have only been received from Madras, Punjab and Bengal. The United Provinces did not put up a note, but in view of the excellent results seen yesterday in the Dehra Dun Forest division, Mr. Smythies has promised to give us his views on the subject. The system of clear felling followed by sowing and planting is becoming day by day more and more the practice in nearly all provinces. Bengal has, I think I may say, as much if not more experience in the question of raising plantations than most provinces and we are now definitely against putting out large pure blocks of species which do not occur pure naturally, and I would ask the provinces who are doing much planting to consider this question of mixtures very seriously. In Madras, experiments have not been taken up on any large scale. They report that mahogany and teak failed in alternate lines mixture, as the mahogany went ahead, killed out the teak and itself became branchy. Strips and groups of line of rosewood and teak failed, rosewood was browsed and died out and the teak on the edges of the strips became very branched. Rosewood is now sown at the same stake as the teak and appears to be doing satisfactorily, and in such an intimate mixture the rosewood does not appear to be browsed so much.

Punjab reports fair success with the mixture of natural mulberry under *shisham.*

In Bengal, no really systematic experiments in mixtures had been taken up before 1932 but individual Divisional Forest Officers had done some good work in this respect. For instance, alternate lines of alder and the *Michelia's*, alder and *Cryptomeria*, alder and *Bucklandia*, have become recognised mixtures for the hills and are doing extremely well. Mixtures other than permanent mixtures have also been in use for some time and such mixtures must be kept distinguished from permanent mixtures. I will give you a few instances of the use of subsidiary species in mixtures, such being either left to die out or removed if they interfere with the principal crop ; thus *toon* and *sissoo*, *Lagerstroemia flos-reginae* and *padauk*, the *toon* and *Lagerstroemia* being used to keep down weeds for the benefit of the light canopied *sissoo* and *padauk.* In order to get a large area under a valuable species such as mahogany, *Bischofia* is often mixed at alternate stakes. Mixed line sowings of *Chickrassia* and *Terminalia myriocarpa* are also made where the *Chickrassia* is used to keep down climbers for the light canopied *Terminalia.* In the Chittagong Hill Tracts, *Gmelina* is used as a nurse crop to different evergreen species with the chief object of affording shade to the latter and to keep down such light demanding weeds as *Eupatorium.* It is treated as a subsidiary species with the possibility of retaining a few stems in the final crop. In 1932, the Central Silviculturist made a detailed tour of our Northern Bengal plantations and pointed out the silvicultural undesirability of putting out plantations of crops with the exception perhaps of *sal* and *khair* which are naturally found pure, and he suggested we should try some experiments with mixed crops. He stated that there are many instances in India where pure plantations have started well and then fallen off and have been lost from damage by insects or quadrupeds, from fungi or uncertain physiological causes and it is these instances which necessitate the closer study of the raising of mixtures. Again in Bengal experience has shown that pure crops of the more intensive light demanders such as *Gmelina, Duabanga, Terminalia myriocarpa* and alder will in later years become so widely spaced as to give a very small volume per acre in the final crop and so may make the growing of them unprofitable. In view of the above and the recent heavy casualties to pure *Michelia champaca* plantation by the pest *Urostylis punctigera,* and to *Gmelina* and *toon* plantations by *Loranthus scurrula,* it was decided to experiment with mixtures on a fairly large scale.

The Central Silviculturist put up a very valuable and exhaustive note on the different methods of mixing in vogue in Europe and other parts of the world. At a Divisional Forest Officers' Conference we selected from this note certain methods for raising permanent mixtures that appeared to be most suited to Bengal conditions as follows :—

(*i*) Mixed line sowing of two or more species.

(*ii*) Alternate plants of two species or alternating plants of several species.

(*iii*) Alternate lines of two species and alternating lines of several species.

(*iv*) Alternating groups of lines (strips) of several species.

(*v*) Group planting of several species, the individual groups being 36′ × 36′.

(*vi*) Matrix of shade bearers with groups of light demanders. The groups of light demanders being 12′ × 12′.

In addition it was felt that when carrying out experiments with mixtures it was essential that the comparative rate of height growth should be studied and this could be most satisfactorily done in one compact area. Therefore in the 1933 plantation at Sukna, in the plains of Kurseong division, a chessboard mixture covering 10 acres and comprising 48 different species were put out by planting or sowing in groups 36′ × 36′, some species being repeated several times and again in 1934 a further 20 species have been tried. Also at Takdah in the Darjeeling division a similar area was put out in 1933 for the most important hill species. All the different methods mentioned above have been put out successfully but it is too early to give any definite results. The following has been noted to date. Group mixtures and the matrix method require a great deal of expert supervision at the time of sowing and planting and for this reason are not likely to be continued. During the cold weather of 1933-34 I visited as many of the older plantations as possible and examined mixtures that had been tried in the past either by design, or by accident (filling up blanks with other species), these were mostly in alternate lines or alternate *thalis* and with species of roughly the same rate of growth. It was obvious that such intimate mixtures were with a few exceptions such as *toon* and *sissoo* most unsatisfactory as they in time always turned into a pure crop of the faster growing species, and besides this there is always the difficulty in deciding what species to favour at the time of thinning. It was, therefore, thought that intimate mixtures with species of roughly the same rate of growth are not as a rule desirable except in a very few cases. On the other hand intimate mixtures of fast growing light demanders and slow growing shade bearers such as *Terminalia myriocarpa* in alternate lines with *Phoebe attenuata,* and *Gmelina* with *gurjan* and *Dichopsis,* etc., show definite promise, besides which such even-aged mixtures have proved themselves to be far more economical and easy to establish than underplanting. Mixed line sowings as a rule were successful except in plantations where field crops giving heavy shade were used.

Our experiments have not gone on long enough for us to draw any definite conclusions as to the best methods of mixing but the following so far stand out as the best :—

1. Groups of lines (strips) of species of roughly the same rate of growth, 5 or 7 lines for those species that grow slower at first and 3 or 5 lines for the faster growers. This method is comparatively simple requiring little supervision at the time of planting and if any one species goes out from any pest the area will be fairly well stocked. Future thinning will be easy as it will only be carried out for the benefit of the trees of the central line of each strip leaving the edges to fight their own battle. It is suggested that not more than 3 different species should be put out in any one area so as to make the marketing of the final crop simpler.

2. Alternate lines of fast growing timber trees such as alder, birch, *Terminalia myriocarpa*, and slower growing shade bearers such as the *Michelias, Bucklandia,* the *Phoebes, Dichopsis,* etc. This method will considerably increase the volume of timber per acre.

3. Mixed line sowings.

I also brought with me a form that the Central Silviculturist and myself drew out for recording progress in experiments with mixtures. It has not been in use long enough to decide its worth, but some such form is essential for recording the progress of these experiments.

In conclusion I would emphasise that the provinces who are doing much artificial regeneration should seriously consider the question of experimenting with mixture of species.

It may be a little more expensive and difficult to raise mixed crops but I am sure it will pay us in the end. I would now propose the following resolution (See page 267).

Mr. Smythies.—Plantation work in the submontane forests of the United Provinces can be classified into 3 types according to the objects of management :—

A. In *sal* forests, for *sal* and other valuable timbers.

B. In miscellaneous forests for timber and fuel.

C. In miscellaneous forests for timber, fuel and fodder.

Dealing with these separately :—

Type A. Plantations in sal *forests.*—These include healthy *sal* forests, where we consider we can again grow fairly pure *sal* crops, and unhealthy *sal* forests where increasing xerophytic conditions and recurring droughts render the creation of pure *sal* crops most inadvisable. In the former we aim at producing a 75 to 80 per cent. *sal* crop with 20 to 25 per cent. of other species, as on silvicultural grounds we do not like 100 per cent. *sal*. The other species are usually *Terminalia tomentosa, Adina cordifolia, Ougenia dalbergioides* and *Eugenia jambolana* and they are grown in intimate mixture. In the unhealthy moribund *sal* areas, we have one of the most difficult problems of plantation management, and we are at present groping our way, and nothing is standardised. The present idea is to dilute the *sal* to an appreciably greater extent by more drought resisting species, and largely deciduous species. Possible species are the first 3 mentioned above, also teak, mulberry and in the worst areas even *Acacia catechu.*

Type B. Miscellaneous forests for timber.—The best examples in the Province are near Haldwani, where there are over 2,000 acres already successfully created, and in the Gonda division where we make about 400 acres per annum. These are all fairly intimate mixtures of species which are found growing natually mixed in these forests, such as *Dalbergia sissu, Acacia catechu, Adina, Bombax malabaricum, Eugenia,* etc. We also usually introduce a little bamboo (*Dendrocalamus strictus*). The species are usually mixed in the same lines, the essential point being that they will all be saleable on approximately the same rotation of probably about 50 years. We cannot possibly mix slow growing species requiring an appreciably longer rotation, even in chess board fashion, as future management would become extremely difficult.

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Type C. Miscellaneous forests for timber, fuel and fodder.—This is an important type in the west of the Province, particularly in the Saharanpur division, where about 1,400 acres of these mixed plantations have been created by *taungya* in the last 4 years. The dual object of management obviously necessitates mixed plantations, and usually one row of a timber species alternates with a row of fodder species. For the former, the chief species so far tried are *khair, sissu, Acacia arabica* (for fuel and bark), *sain, Bombax, etc.* For fodder figs, *Kydia calycina, Ougeinia, Bauhinia* spp. *Terminalia belerica, Albizzia* spp., also bamboos.

It is fortunate that most of the timber species are excellent for fodder as well, and *vice versa*, so the mixture by lines will give great flexibility in future management, as many lines can be utilised either for timber or for commercial lopping. The demand for commercial lopping is practically unlimited, and from this source alone we expect to obtain an early recurring revenue of Rs. 2 to Rs. 4 per acre per annum on land which at present holds a crop worth perhaps Rs. 10 per acre all told, and which we can convert into completely successful plantations at an all-in cost of Rs. 4 to 10 per acre by *taungya*.

Summarising results for the whole province :—

In the A type, *sal* forests, we expect within a year or two to reach the 1,000 acres per annum mark, the bulk of this being in the Eastern Circle. In the B. type, miscellaneous timbers (including teak in the Eastern Circle), we shall also be approaching the 1,000 acres per annum mark (including the Government Estates forests of Naini Tal district). In the C type, miscellaneous timbers and fodder, the area sown up last rains was very nearly 1,000 acres, mostly in the Western Circle. I would like to emphasise that with the solitary exception of teak, which we usually try to grow pure, all our other plantations are now being created as fairly intimate mixtures. All we do try to insist on is that species which will have to be grown on very different rotations and which therefore will ultimately have to be allotted to different working circles, are kept totally distinct and if possible in different localities. This note will indicate the extreme importance of mixed plantations to the United Provinces and we shall endeavour as far as possible to co-operate with other provinces in any research work required.

Approximate areas of plantation work per annum in the United Provinces.

Division	Type A Sal plantations.	Type B Miscellaneous timber.	Type C Miscellaneous timber and fodder.	Total.
	Acres.	Acres.	Acres.	Acres.
Gorakhpur	400	..	..	400
Gonda	200	400	..	600
Bahraich	100	100	50	250
North Kheri (teak in *sal* forest)..	..	100	..	100
Total Eastern Circle ..	700	600	50	1,350
Haldwani	100	250	..	350
Ramnagar	200	..	..	200
Lansdowne	..	..	100	100
Dehra Dun	..	..	100	100
Saharanpur	50	..	550	600
Total Western Circle ..	350	250	750	1,350
Tarai and Bhabar Estates Forests	50	250	..	300
Grand Total ..	1,100	1,100	800	3,000

Note.—This does not include about 500 acres per annum of plantation along the Ganges Canal banks, in the Afforestation division, which are being created for the Irrigation Department.

Chairman : (Mr. Gilbert).—May I know how long these mixed plantations have been tried in the United Provinces ?

Mr. Smythies.—Plantations were started in Gorakhpur about 15 years ago. The rest of the work was started by Mr. Howard some 7 years ago. So that we have not got very old plantations. Nowhere have we got anything over 15 years and those we have got practically all date from 5 to 7 years.

Mr. Homfray.—One thing I should like to ask Mr. Smythies specially with regard to his type B is exactly how he proposes to do his thinnings. Why in Bengal we take all the trouble to go into this detail of research is because we have seen on the ground that with intimate mixtures of species of roughly the same rate of growth that such mixtures usually turn into a pure crop of the faster growing species. It is practically impossible to thin such mixtures satisfactorily. In Bengal we feel that all this trouble and expense will be saved if we find out how to get the different mixtures required without this intimate competition in growth.

Mr. Smythies.—The mixture that we have most commonly is *Bombax* with *Acacia catechu* which is not likely to give trouble this way.

Mr. Laurie.—The only intimate mixture that we have tried in Madras with teak is rosewood which is raised at the same time as the teak and in this case you have the condition where the teak grows fast and the rosewood grows slow and the two remain in different canopy layers, at any rate in the early stages. Mixtures by strips and by groups have been prescribed in several working plans for areas that we do not know are definitely suitable for pure teak plantations. Teak is usually one of the species we use, but *Swietenia macrophylla, Artocarpus hirsuta, Pterocarpus marsupium* and rosewood are also used in these mixtures. The subject has not yet been systematically studied and we do not know what is going to happen. Regarding methods of research I think it is chiefly a matter of trying out different methods and species and gathering experience from the results we get and from what other people have done.

Mr. Champion.—This seems rather an appropriate point in which to interpolate a remark. The question of research methods in mixed plantations is really what we are discussing and it is because of past failures to get the maximum information possible from the divisional experiments that our attention has been drawn to the necessity of doing something systematic about it. The commonest form of mixture or one that we hear most about and which looks like being displaced is the strip-wise mixture. Several provinces have them on quite a big scale as for example in Burma for which I think Mr. Barrington was responsible. Failures have been usual and on quite unreasonable grounds, as I view it, the failure has been ascribed to the particular form of mixture tried. Now the immediate causes as a rule have been something quite different. The Madras rosewood strip experiments failed because of browsing, the Burma ones referred to failed apparently from similar causes, including the planting of species that were unsuitable for the site. There are a lot of places where we have crops on the ground and we ought to be able to draw a lot of information from these, but usually when we try to get it we are defeated by the absence of a clear record of what has been done, how it has been done, and when it has been done. A change of policy is the very commonest difficulty. In a two species mixture, the first officer favours one species and the second the other. The result is to spoil the first one and then the other. As long as you have the same divisional officer you can usually keep track of what is happening, but directly there is a change of officer, if the record is not complete, and unless you have a definite portion of the plantation demarcated on ordinary research lines, you will find that you miss a great deal of information. So I am very keen, even where these mixed plantations are being put out on a big scale, that certain portions of them should be kept under a definitely systematic investigation with a very clear policy as to what is to be done. If the policy is doubtful then you should lay out more than one plot to provide for later differential treatment. The case, as we saw, of the plantations yesterday is rather different in that as a rule the timber requirements are either confined to one species as we saw with the *semul* or we have the subsidiary object of lopping, in which case again timber production can perhaps be relegated a little into the background. But in most of our plantations timber is our first and only consideration.

One point which Mr. Homfray raised which would be of interest to anybody who has dealt with these things is that in practice he found the groups-in-matrix method too difficult for the staff. Of course there may be difficulties if you insist on very accurate spacing of your groups but their distribution only roughly evenly over the area will suffice and it should be possible to put out stock in this way. I think that such details become very much easier after a little practice and would very soon be done automatically.

Mr. Howard.—I would like to say that while I completely agree with what Mr. Champion has said about observing things scientifically, I am unfortunately bound to confess that we have got to such a stage in our research work that every thing we take on now means that we have got to throw out something else and it is a question of relative importance.

Mr. Champion.—That of course I accept at once as a sound reason for not taking it up, but I would ask that the possibilities and the necessity should be borne in mind.

Mr. Howard.—We are tackling a whole lot of forests where only a few species are valuable per acre and they are very scattered and what we are trying to do is to raise closed forests in their place. We have to decide what species are worth growing and what to grow on the different types of soil that we encounter—soils are very variable. I can find a certain number of species which I know are valuable for forest purposes and I know I can grow things like *sal*, *Bombax* and one or two others and even *khair*, but my trouble is that every one of these species which I know are valuable is a species which will not form a closed crop, and I am defeated. I can grow all these trees as scattered standards but what am I going to have to fill up between and underneath ? Even *khair* will not do and at the present moment the only suggestion is mulberry.

Mr. Trevor.—I can tell you that mulberry when selling at a very moderate price is sold at 4s. per c. ft. The present demand for mulberry is greatly in excess of the supply. I told Government that mulberry appears to be the most profitable crop of the Punjab and they had better see whether they cannot find areas in the rainfall belt where they can extend its cultivation. I think if you can grow mulberry that would be accepted by the Sialkot sports trade you would find it a very valuable crop.

Mr. Howard.—The mulberry supplied at the moment is a special type. The point is that you are supplying a luxury trade and when you really get down to thousands of acres of plantations you will very soon swamp that trade. Will the mulberry be of use as a chief lumber and can we produce it ? If we can then it does not matter how much we put down.

Mr. Trevor.—I published in the *Indian Forester* statistics worked out here comparing English ash and Changa Manga mulberry timber and the report on our Changa Manga mulberry was that it was the equal in all respects of English ash and was slightly lighter in weight, so that you can take it that for any purpose for which English ash is used in Europe you can use mulberry in this country. In addition it can be used as firewood, it can be used for all small timber purposes because you are not going to grade it as large timber, and you will be able to go a long way before you swamp the sports trade at Sialkot. There have been enquiries from South Africa and from Australia asking for the supply of the Punjab mulberry.

ITEM 24.

Technique of teak plantation work.

Papers were received from Burma (below), Madras (p. 290), Bombay (p. 297), Central Provinces (p. 301) and Bengal (p. 305).

The item was introduced by Mr. Ramiengar (Mysore) speaking mainly on the procedure in Mysore and there was a lengthy debate (p. 308) in which the chief points discussed were spacing and early stump planting, representatives of most provinces and States taking part.

The following resolution was proposed by Mr. Ramiengar, seconded by Mr. Sampson (Dangs, Bombay) and passed by the Conference.

RESOLUTION ON ITEM 24.

Resolved that—

The Central and Provincial Silviculturists should collect available information published and draw up a general programme to systematise further research in close co-operation with the territorial staff.

* * * * * * * *

PAPER (I).

Contributed by R. W. V. Palmer, *Silviculturist, Burma.*

A summary of current methods in vogue with reference to soil and climate and reasons for any changes in recent years and a note on costs to the age of 5.

I. General.

1. All plantation work in Burma is done with the assistance of *taungya* and there is no regular plantation work.

The most comprehensive general account to date is in Mr. Blanford's "Regeneration with the Assistance of *Taungya* in Burma". (*Indian Forest Record,* Volume XI, Part III, 1925).

In the main this record holds good in Burma to-day. The information added in the summary below should, therefore, be read with it. Information as to current practice to-day has been kindly supplied direct by Divisional Forest Officers in charge of the following principal teak planting divisions.

2. These divisions are divided roughly into zones as below :—

Northern.	*Central.*	*Lower Burma.*	*Tenasserim.*	*Arakan.*
Katha (Mr. Manning).	Pyinmana (Mr. Sayres).	Zigon (Messrs. Woods and Clarke).	Ataran (Mr. La Touche).	Arakan (Mr. Castens).
Bhamo (Mr. Morehead),	N. Toungoo (Mr. Pudden).	Tharrawaddy (Mr. Rooke).	Thaungyin (Mr. Barrett).	
	Prome (Mr. Greenep).	Insein (U Hman).		
		S. Pegu (Mr. Butterwick).		

Northern. The wet zone of Upper Burma. Rainfall 70—80″. Nearing the northern limit for teak.

Central. The northern part of the Pegu Yomas. Rainfall 48—65″. Probably the optimum for teak.

Lower Burma. All within 150 miles of Rangoon. Rainfall 60—90″. Heavy soils.

Tenasserim. Rainfall 100—200 inches and monsoon generally continuing later than in Lower Burma.

Arakan. Rainfall over 200 inches. No natural teak. Principally bamboo forest (*Melocanna*) and evergreen.

II. MEASURES PRELIMINARY TO REGENERATION.

3. It is now usual for proposals for concentrated regeneration to be included in the Working Plan and blocks allotted thereto. Before regeneration can start the area has to be stockmapped and a felling *cum* regeneration plan based on it and passed by the Conservator. Teak has to be girdled and teak (and hardwoods where marketable) have to be extracted.

Orders for stock mapping, etc., are contained in Chief Conservator of Forests' Circular No. 2 of 1925 which is also embodied in the Manual for Forest Subordinates and is, therefore, readily available to all and is invariably followed. A copy is attached. The following are explanatory as regards this Circular :—

4. The tendency lately has been to increase the minimum period of 7 years ahead of regeneration, by which girdling has to be done, to 9 or 10 years.

In order—

(*a*) to avoid rushed extraction due to delays or failure on the part of the extraction agency.

(*b*) to give the forest a year or two of rest and, where possible, protection from fire to recover from extraction and to improve the burn. This has resulted in some cases in the Exploitation *cum* Regeneration Plan being extended to 12 years. A drawback is the sacrifice of increment of teak by earlier girdling and the tendency to extend the period is mainly a reaction against the trouble experienced in the early days in completing extraction in time.

In practice it has been found that stock mapping on the scale of 8″ to 1 mile is sufficient, and in some cases simple outline enlargements of the 1″ map to a scale of 8″ = 1 mile have been made by the Dehra Dun map office, ten to twelve copies being ordered so that they were available for Range Officer, Compartment Register, etc., etc.

The actual felling *cum* regeneration schemes passed and approved have in some cases been embodied in the Working Plan (see Working Plan for Tharrawaddy for the period 1928-29 to 1942-43 where good examples with a slightly improved Form A & B will be found).

Opinion is now against planting teak in dry upper mixed deciduous forest. The growth and general health of plantations made therein have been very disappointing. It is also generally considered that heavy clay soils do not produce good teak plantations at any rate by *taungya*.

In low lying plains reserves (*e.g.*, Tharrawaddy) a contour map is also made as decision as to species to be planted in this case depends entirely on minute differences in levels and consequently in flooding.

Note.—The expression '*wathon*' means dense growth of immature bamboo, the result of flowering.

III. WORK IN THE FIRST YEAR.

(*a*) *General. The Yearly Round.*

5. The rains throughout Burma last from late May to October or November, and are followed by a rainless period till March and thunderstorms in April or May. There is little difference between the annual programmes for different centres. At many centres superstition requires and *ya* cutting start before the beginning of *Pyatho* (end of December) and everywhere apart from the weather, *yas* must be burnt before the Burmese New Year festival begins (10th—12th April) ; the rice crop is reaped in November and December. Generally dates are a little earlier than in the appendix to Mr. Blanford's Record.

A typical programme (North Toungoo) is given below :—

Time table of *taungya* operations.

Allotment of *ya* plots	15th December.
Beginning of *ya* cutting	27th December.
Bamboos completely felled	15th February.
Whole *ya* felled by	25th February.
Seed collection begins	15th March.
Stake collection completed	31st March.
Ya burnt	3rd April.
Nurseries broadcast	6th April.
Kyunkwe begins	6th April.
Staking begins	12th April.
Seed collection ends	15th April.
Sowing at stake begins	15th April.
Staking complete	25th April.
Sowing complete	30th April.
Survey made during May	
'*Mi-paung*' weeding in May or early June	
Sowing of paddy when heavy rain has fallen	
Paddy reaped in October	
Teak plants counted early in December.	

The dates given vary a few days either way but the variations over five centres and a period of years is not great and the above are average dates, with the exception of April 30th by which sowing must be complete.

Felling of yas.—*Ya* cutting is done in three stages. Firstly the underlying herbaceous and smaller woody growth is cut, secondly the bamboos are felled, and thirdly the large trees are felled. A fire line is made and kept clear all round the felled *ya*. Felling of bamboos into streams is checked as far as possible, this being a common fault.

Burning of yas.—High winds are invariable at the usual time of *ya* burning. For this reason fire is first applied on the lee side because burning from the windward side would result in a very quick but incomplete burning. Firing is continued round the *ya* on each side until it is burning from every side.

Every subordinate and villager available attends the burning because elaborate precautions must be taken to prevent fire spreading into or being blown into the very inflammable and usually very adjacent *bizat* (*Eupatorium*) infested *yas* of previous years.

(*b*) *Collection of seed.*

6. Collection of seed has received more attention recently in view of the publication of the Indian Forest Bulletin 78. "The Importance of the Origin of Seed used in Forestry ". Care is being taken that :—

(*a*) Seed is collected only when the main crop is falling, *i.e.*, 15th March onwards.

(*b*) Collection does not get into the hands of contractors not living in the forest and is supervised by subordinates.

(*c*) Collection is only made from healthy good quality forest of medium age.

(*d*) Seed is up to size for the locality. Small seed provided well formed and healthy is not rejected. In Ataran suitable seed bearers are selected and marked and collection made yearly from the same trees. In South Pegu divisional elephants are used to bring seed collected from good forest elsewhere.

(*c*) *Preparation of seed before sowing.*

7. Still in the experimental stage. The last published results are contained in *Burma Forest Bulletin No. 24* of 1931 to which reference should be made. Some form of preparation is adopted at most centres, the simplest consisting of exposure of the seed in heaps, sometimes covered with straw and leaves, in the *yas* immediately after the fire and spreading out after the first showers. Experiments indicate that soaking in tins 12 hours and spreading out to dry 48 hours repeated 5 times and sown with the first showers generally gives fair results. (Adopted as standard in South Pegu). Burying in pits is too uncertain. In Katha general use of stumps and less need for early germination has led to abandonment of special measures. Previously seed was buried a year in a dry place below a hut before planting.

(*d*) *Spacing.*

8. Six foot by six foot is standard for teak and has been for some time. There is however a feeling that 9′ × 4′ or even 12′ × 3′ may be preferable and experiments at 4 centres have been laid down to test this as regards weeding and thinning convenience and convenience to ya-cutter's crops.

In Arakan, where *taungyas* are cut in *kayinwa* forest, (*Melocanna bambusoides*) planting on the hill sides is carried out in bands of 5 rows staked 6′ × 6′ and bands 30 feet wide (corresponding to 3 rows 6′ × 6′) are left unplanted. The bands follow the contours. This spacing has been adopted for the last 3 or 4 years.

Mr. Castens notes on this as follows :—

> " It is possibly worth noting on the effects of Arakan spacing on teak growth. The bands of 3 rows left unplanted contain a growth of *kayin* bamboo. This grows up parallel with the teak and given reasonable care in weeding neither overshadows it nor allows it to branch unduly to the sides. So far I have had no need to cut this strip back. I did so on a part of the 1931 *yas* at the end of 1933, and then stopped as it was undesirable leaving the outside edges of the teak bands unprotected. This spacing saves weeding cost slightly though the effect is not marked as I have insisted on more thorough weeding of the teak bands.
>
> The reason for leaving these bands is that a good stock of teak and good weeding kills out the *kayin* bamboos under the teak leaving a bare forest floor. With a good *kayin* bamboo undergrowth cleaning trees automatically to forty to fifty feet, thinnings in crops 20 years and over can be very heavy resulting in wonderful girth increment. During the opening of the crop in the first, second and third thinnings *kayin* bamboo will creep into the crop from the uncut bands and form a complete understorey eliminating erosion and enabling heavy thinnings to be made later."

(*e*) *Sowing and Planting.*

9. Different methods have been evolved to suit different conditions and are as below :—

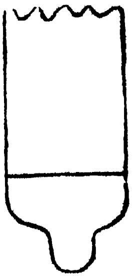
(*i*) Sowing direct at stake. Practised in Pyinmana and Prome (complete by 20th May) and North Toungoo (complete by end of April). Rainfall in these divisions lies between 45 and 65 inches and there are liable to be dry hot spells in June. Mainly for this reason sowing in nurseries and transplanting later to stake is not favoured.

Direct sowing (complete by the end of April) is however also adhered to in Thaungyin (100 inches rain) and Ataran (200 inches). In the latter case germination is very consistent and there may be no real case for changed methods.

Direct sowing at stake must however be regarded as somewhat behind the times and less likely to produce even growth or spacing than (*ii*) below.

10. For direct sowing three seeds are usually sown round the stake and 6″ to 9″ from it in a small hole made with a trowel. The seed is firmed in with soil with the foot of the operator to just below ground level. Usually the *ya* cutter goes ahead preparing the holes and is followed by his wife or daughter, who drops and firms in the seed.

11. At Natchaung (Ataran) a hole is made in the soil with a special stick the *ya* cutters have made for themselves. It is about four feet long and 1½″ in diameter. It is shod with a metal tip which has a one inch boss about the diameter of a teak seed (see diagram). The boss is pressed into the soil and makes a notch into which a teak seed is pressed with the thumb and lightly covered with earth. The object is to prevent the seed being washed away by the heavy rain which pours down the hill sides at the beginning of the rain.



12. (*ii*) Sowing in nurseries and transplanting later to stake (one seedling).

This is standard in Zigon, Tharrawaddy, and Insein where the monsoon breaks about 20th May and rain thereafter is usually continuous. Rainfall 60″—90″. Transplanting is usually completed about mid-June. Mr. Murray Woods (Zigon) notes :—

> " Nurseries should be on a slight slope and soil must not be friable ; otherwise transplanting is too difficult. Teak seeds should be heaped in them until the first showers and then spread. It is a moot point whether the seed should be spread thickly (this accelerates germination, but causes considerable wastage in transplanting) or thinly, with the opposite result. Personally I favour the former—teak seed is not expensive. The earlier the seed is transplanted the better. I am still in favour of transplanting when the radical emerges from the seed. though I am aware that there is strong opinion against this. (*Note* :—based chiefly on possible breaks in the monsoon.) The importance of transplanting the larger seedlings with a good ball of earth requires no emphasis It is important, when transplanting to see that *ya* cutters put the transplants in at each stake in the same relative position. *i.e.*, each plant should be either north, south, east or west of the stake. Otherwise lines become very irregular. One transplant per stake should generally be sufficient. provided that systematic inspection and patching is carried out at least three times during the rains ".

Mr. Clarke (Zigon) notes :—" Early planting is commenced as soon as the teak seed splits and the radical emerges. but before the roots appear so that seed can be carried without any damage being done the roots. the soil near the stake being slightly loosened. Later transplanting takes place as soon as the monsoon has properly set in and two leaves per seedling have developed. The seedlings are lifted from the nursery with a ball of earth round the roots care being taken not to damage the roots ".

In Tharrawaddy and Insein. seedlings are usually moved from the nursery with balls of earth (ball method) when they have produced 2 pairs of real leaves.

Shortage of water in April is usual and it has not yet been found practicable to tend and shade nurseries during this period in order to secure earlier seedlings.

13. (*iii*) *Use of stumps.*—This is the standard practice in Northern Burma (rainfall 70″—80″) and has replaced other methods entirely owing to the uncertainty of germination of seed.

Mr. Manning (Katha) notes :—" Stumps planting is normal. Seed is broadcast on beds dug 6″ deep by the *ya*-cutters on the edge of the *ya* of the year and on the side towards the next year's *ya*. Each man should prepare sufficient beds for his stumps for the next year. The beds should be kept weeded. Late germination is not serious as the stumps are all sufficiently vigorous the following year. It is not important to have the seeds widely spaced, so long as they have room to grow and produce shoots. The stumps are put out as soon as the *kyunkwe* is finished and should not be planted unless there is moisture in the soil. We lay off as soon as there is drought. This point is not important and " the really important thing is to get the stumps planted in April if possible : the earlier the better the growth although slightly more casualties must be expected. It is most important that the stump should be well firmed in and that this should be repeated when the soil gets moist to prevent waterlogging and rot. Covering the stumps with a little earth adds to the growth if the stumps are put in really early when the sun dries them out a lot. Covering with earth is not beneficial when planting in the middle of May as it tends to help rot. Stumping is done in usual way, 6″ carrot and 2″ above collar. Patching of stumps is done about 15 days after planting if there has been any rain to induce sprouting otherwise the stumps may remain without shoots till 12 days or so after rain and this may be as long delayed as the middle of May or 50 days after planting. A really determined effort to patch all blanks is made at the end of May normally when the rains have really broken ”.

14. Stumps are also being used in Arakan (200″ or more) where seed supply has to be sent from Burma. The following is an extract from orders issued by the Divisional Forest Officer, Mr. Castens :—

> “ The *yas* will be burned by the 7th April and staking will be completed by 10th May. As soon after 25th May as the ground has been well moistened by rain, stumps will be planted. Stumps will be lifted and prepared by the *ya*-cutters. The stem must be cut one and a half inches above the place where the stem enters the ground. All small roots must be trimmed off and the tap root cleanly cut below its thick part. They will be lifted during the morning and planted in the afternoon. The subordinate in charge of the work will inspect all stumps lifted and reject all stumps which have been damaged and all stumps made “ from plants with a stem larger than ½″ diameter. He will see that stumps are planted only to the same depth as the original plant, and that the earth is pressed back firmly round the stump. Planting stumps must be finished by the time the first weeding of the paddy is due. This is normally about June 10th. During the first weeding of the paddy all stumps must be inspected and blanks marked with a four foot stake. Blanks must be patched with two stumps each as soon as they are found. The number of blanks patched in each *ya* must be recorded. During the second weeding stakes will be again inspected blanks marked with a four foot stake and patched as soon as found with two stumps. The number of blanks patched in each *ya* will be recorded. No further patching is usually necessary.”

(*f*) *Broadcast sowing of accessory species.*

15. The object of this is clearly stated in Mr. Blanford's Bulletin, Chapter V. 1 (*vi*).

Technique has not advanced greatly in the last 7 years. Reasons are possibly the universality of *bizat* (*Eupatorium*) in *taungyas* after the first year ; the reluctance of subordinates to disregard the accessory species when weeding and feeling that a secondary use is to retain the crop as an understorey especially in accessible areas. The two latter reasons have tended to obscure the effect on weeding costs which is the primary object. There are also doubts as to the effect of root competion on the major species.

16. Notes from Divisions are given below :—

Katha.—Not needed owing to the fast growing of teak and the rapid closing of the canopy.

Zigon, Binga (*Stephegyne diversifolia*) collected and broadcast in the *ya* does not germinate as well as naturally fallen seed and seed bearers are left standing. Mr. Murray Woods notes that *binga* and *pyinma* should be more thickly sown than at present. Broadcasting by subordinates and not *ya*-cutters who simply drop the seed in heaps.

Prome.—In the past *thinwin* (*Pongamia glabra*), *Nagye* (*Pterospermum semisagittatum*), *binga, pyinma* and *thanthat* (*Albizzia lucida*) have all been tried. *Thanthat* grew too fast and made weeding difficult. None very successful and to-day cutch is the only accessory species used and is useful where growth of teak is likely to be poor *i.e.*, on clay ridges.

South Pegu.—After the paddy has been sown and the young shoots have sprouted, *binga* seeds are broadcasted along the lines of pegs. In low lying places *sit* (*Albizzia procera*) is planted at stakes 6″ × 6″ and *pyinma* broadcast. Other accessories used are *myaukchaw* (*Homalium tomentosum*), *Thitpayaung* (*Nauclea excelsa*), *htein* (*Stephegyne parvifolia*) on well drained soils, and *pyinma*, and *mau-kadon* (*Sarcocephalus cordatus*) in lowlying places.

Northern Shan States.—*Tephrosia candida* was tried as a cover crop but failed. (Note :—There has been no great success in Burma so far with *Tephrosia* which does not appear to seed freely).

Ataran.—On hill tops and where the soil is poor, as well as in places where there is *thetke* or *pyaungsa* grass, *pyingado* is sown quincunx but not paid for. In marshy places *pyinma* is broadcast, and *binga* is broadcast all over the *ya*. The subsidiary species are sown during June, the actual date depending on the amount of rain.

North Toungoo.—*Binga* is broadcast after the first good showers as a future understorey for teak and as a weed suppresser. In low-lying places near streams *pyinma* is broadcast but has rarely been successful. *Binga* has a marked tendency to survive in patches, coming up in dense masses in some places and failing completely in others.

Thaungyin.—*Binga* has been tried in the last couple of years without great success. Scarcer than in the Pegu Yomas, it is difficult to get enough.

Note :—The above refers to accessory species and not to mixtures which are not considered here.

(*g*) *Weedings and filling up gaps.*

17. The *ya*-cutter is responsible for keeping all useless weed growth down during the year of planting with special attention to bamboo not properly killed by the fire. He does one weeding (*mi-paung* before sowing his rice and further weedings (*sababaung*) at intervals through the rains.

Mr. Pudden comments on these weedings as follows :—

> " As a result of the early showers there appears in May a growth of weeds, mainly coppice shoots from trees and bamboos, but also creepers, which are removed. In all weeding of coppice shoots a '*tuywin*' is employed by striking down at the base of the shoot, which is thus torn away from the stump. In the later weeding when the paddy is still small this method is employed and all weeds are placed on bamboo stumps to retard by shading the development of further shoots ".

18. Mr. La Touche's account of filling up gaps at Natchaung (Ataran) gives in detail the accepted practice at this well organised centre where sowing at stake is practised and the technique applies equally well to planting with seedlings or with stumps.

" This is the most important operation of all and the success of the plantation depends on the thoroughness with which it is carried out. All the *ya*-cutters patch up their *yas* before the end of June during the first *sababaung*. They take the seedlings required either from their nurseries or from stakes where there are two or three seedlings. They use trowels and have been taught Mr. Blanford's improved method of two semicircular vertical cuts and an oblique cut to lift the seedling. During the first *sababaung* they also nip off surplus seedlings where more than one has germinated from a single seed. Three seedlings from a seed are quite common. In marshy places it is now the practice to put in a *pyinma* seedling as well as a teak seedling at blank stakes so that if the teak fails there may be some tree in the gap.

" During the first week of July—not too soon after the *ya*-cutters' patching so that badly transplanted seedlings may die in the meantime—all available subordinates are collected and carry out the first inspection for blanks. This is also a very important operation because blanks filled properly now will give no more trouble, and later in the year it is more difficult to find blanks when the paddy is high and transplanting the large seedlings is difficult to carry out successfully. The subordinates carry 5′ stakes (the normal stake is about 3′) which they insert at all stakes where a blank is found. The *ya*-cutter transplants a seedling to fill up the gap, and when he has done so he bends over the top of the long stake to show that he has dealt with it. Ten days or more later a subordinate, when he has time, inspects the transplant and if the seedling is successful he removes the long stake. If the seedling is not successful he breaks off the tip of the stake previously bent over—leaving a whole stake—or he transplants a seedling himself. Usually the *ya*-cutter accompanies him and fills up the few remaining blanks at once. The whole procedure is gone through again in August.

Methods adopted in Katha and Arakan for stumps have already been given above at paras. 13 and 14 above.

(*h*) *Reaping crop and counting.*

19. Nothing fresh to add. The standard set for a live seedling at counting is that it should be strong enough to survive the following hot weather. Ninety per cent. live plants is now a common-place.

20. A set of order sheets distributed to Range Officers in Tharrawaddy and Zigon is attached. Their object is to keep the time table of work up to the mark. Their use is not standard for all divisions.

IV. WORK IN THE SECOND AND SUBSEQUENT YEARS.

(*a*) *Second Hot Weather.*

21. *Taungyas* are not burnt now in the second hot weather. In Bhamo where stumps are used for planting and early growth is very strong it is usual for forest subordinates to coppice the whole *taungya* in March. By the end of June plants coppiced in March show an average height of 5′—7′ clean stem.

(*b*) *Second year weedings.*

22. *Bizat* (*Eupatorium*) appears densely in nearly all *taungyas* at the beginning of 2nd rains and weedings are principally needed to keep the teak free during the season of fastest growth (June and July). There is usually a slowing down of growth in August|September and a final increase in growth in October.

In Katha and Bhamo where the growth from ‘ stumps ’ is strong, one weeding in June followed by creeper cutting and selective weeding in September is sufficient. Elsewhere 3 weedings are usually needed. The first weeding takes place about end of May or beginning of June when the rains have set in, and patching blanks with stumps is done at the same time. The second weeding is in July or August depending upon the weed growth. A third weeding and climber cutting usually selective is done in September.

In South Pegu very early first weedings (1st half of May) are favoured and in Pyinmana the 3rd weeding is deferred to December.

(*c*) *Third year weeding.*

23. In Katha one weeding about June and climber cutting later is sufficient and in Bhamo work is largely confined to climber cutting. Elsewhere the 1st weeding is usually in June but may be later and the second in August or September and is largely selective.

(*d*) *Subsequent years.*

24. In good *yas* climber cutting is all that is likely to be needed until the plantation is thinned. All young plantations are however examined yearly until at least the tenth year or until a second thinning is due as it is found that after the 1st year or two few plantations remain sufficiently uniform to justify uniform treatment. In the proper plantations selective weeding and clearing has still to be done for some time.

V. COSTS TO 5 YEARS OLD.

25. The following extract from the Annual Report for Silviculture for 1933|34 summarised the position :—

Establishment of Regeneration.—The following table gives the cost per acre up to 5 years for all work on plantations formed between 1929-30 and 1933-34 for some representative divisions in which plantations have been reasonably well organised for some time. Costs are averaged, *i.e.*, formation 1929—

1933, 2nd year 1930—1933, 3rd year 1931—1933, etc. In brackets are given for comparison where possible averages for the five year period ending 1929-30 taken from para. 31 of the Annual Report for that year.

Divisions.	Cost of formation rupees and decimals.	Cost in rupees and decimals per acre in the				Total cost of establishment per acre up to 5 years. Rupees and decimals.
		2nd year.	3rd year.	4th year.	5th year.	
1	2	3	4	5	6	7
Tharrawaddy Yomas	15·1 (17·9)	5·2 (5·6)	3·6 (4·5)	2·8 (3·0)	2·5 (2·9)	29·2 (33·9)
Plains	16·0 (27·6)	1·7 (1·5)	3·3 (3·0)	2·0 (2·2)	1·7 (1·9)	24·7 (36·2)
Prome Yomas ..	13·5 (12·5)	3·7 (6·4)	3·9 (4·5)	3·8 (3·4)	1·0 (2·2)	25·9 (29·0)
Zigon Yomas ..	14·3 (17·2)	4·6 (6·0)	3·2 (5·1)	2·0 (3·7)	1·2 (3·3)	25·3 (35·3)
Zigon Plains ..	14·7 (16·9)	4·8 (6·0)	4·0 (4·3)	2·4 (3·4)	0·8 (2·5)	26·7 (33·1)
Insein Yomas ..	15·5 (11·7)	4·3 (7·3)	3·4 (5·6)	1·1 (4·3)	0·4 (2·3)	24·7 (31·2)
N. Toungoo ..	15·0 (14·9)	5·7 (5·3)	3·3 (3·5)	1·5 (1·1)	1·2	26·7
S. Toungoo (Midaingtaw).	14·1	5·0	3·6	2·4	2·8	27·9
Ataran .. .. (Natchaung).	14·1 (12·1)	4·7 (4·7)	2·9 (4·7)	1·7 (3·9)	0·7 (2·1)	24·1 (29·1)
Pyinmana	11·7 (12·1)	3·6 (4·3)	2·1 (2·2)	0·7 (1·3)	1·6 (0·6)	19·7 (20·5)
Minbu (cutch) ..	5·9	3·0	1·6	0·4	0·1	11·0

There is no general fall in formation costs, as rewards at the majority of centres have not been lowered and stocking has improved. These costs are however more nearly grouped round the thirteen rupees mark than they were. Increases in formation costs in Insein and elsewhere (Thaton Rs. 21.6 per acre, South Pegu Rs. 20.6 per acre) are due partly to adoption of double stocking but the big drop in subsequent costs in Insein cannot safely be attributed to this.

In certain cases the greater care taken over seed collection has increased cost.

Maintenance of a scale of reward to give a good *ya*-cutter Rs. 30 to Rs. 40 for his season's work is desirable and necessary at most centres but rewards much in excess of this for double stocking are less easy to justify.

Second year costs have fallen generally in about the same proportion as daily labour rates but improved stocking and technique should reduce third, fourth and fifth year costs over and above this. It is noticeable that costs are still heaviest in these years in Tharrawaddy, Zigon and Prome whose plantations suffered most from fires during the rebellion.

An average for Lower Burma *taungya* work on standard lines seems to be about twenty-five rupees to five years old as against thirty previously.

Northern Burma costs are lower. Rewards are lower and the very rapid growth cuts out most expenses after the 3rd year. Other specialised work such as the Twantekondan and Delta *yas* also cost less, the latter being Rs. 11.4 to the age of five.

Item 24.]

PAPER (II).

By M. V. Laurie, *Silviculturist, Madras.*

Summary of current methods of raising teak plantations in Madras.

I.—*Nilambur division*—

(*i*) *First Rotation Plantations.*—

(*a*) *Locality factors*—*Rainfall* 120 inches ; *Soil*—Sandy alluvium on the flats near the rivers changing to poor incompletely decomposed laterite on the low hills.

(*b*) *Clear felling and burning*—done departmentally in November to January. (There is no taungya in the regular teak plantation work at Nilambur though several small experiments have been made)—*Cost* Rs. 16 to Rs. 23 per acre—average Rs. 18-13-0.

(*c*) *Aligning and staking*—6 ft. × 6 ft. espacement is invariably adopted. *Cost* Re. 0-10-8 to Rs. 2-10-7 per acre—Average Rs. 1-12-7 approximately.

(*d*) *Method of stocking.*—The former method of entire transplanting which was the rule up to four or five years ago has become progressively less popular, being less reliable than stump-planting and more expensive than direct sowing. At present most of the first rotation plantations are raised by direct sowing in worked patches (about 18 inches diameter and 4 to 6 inches deep) at the rate of 9 to 12 seeds per patch. 20 per cent. to 25 per cent. casualties are usual by this method.

Cost.—

(*a*) *Seed collection*—Re. 0-12-2 per acre approximately.

(*b*) Soil preparation and sowing Re. 0-12-3 to Rs. 2-1-4 per acre, Average Rs. 1-2-9 per acre.

(*c*) *First year weedings*.—A weed cutting is done in July or early August over the whole area the weeds just round the teak plants being pulled up to a radius of 18 inches or 2 feet. In September a forking 3 to 4 inches deep in four foot diameter circles is done with weed cutting in the rest of the area. A pruning and cutting back of damaged plants is done in April to May. The total cost of first year weedings is from about Rs. 14 to Rs. 21, the average being about Rs. 17-4-0 per acre. Miscellaneous charges such as cutting drains in swampy areas, protection from monkeys, etc., average about 12 annas per acre.

(*f*) Replacement of casualties is done during weedings by transplanting spare seedlings from one stake to another in rainy weather, supplemented by nursery seedlings where necessary The cost is from Rs. 1-1-0 to Rs. 1-15-3 as a rule, average about Re. 1-0-0 per acre.

(*g*) *Second year tending.*—Blanks are filled in May with stumps. A complete weed cutting is done and plants below 2 feet in height are usually forked round to a diameter of 2 to 3 feet from end of July to September, and a pruning is done in the following May. Cost—Rs. 4-8-0 to Rs. 8-0-0—Average about Rs. 6-10-0.

(*h*) *Third year tending.*—This is usually limited to climber cutting—Cost about Rs. 1-8-0 per acre.

(*i*) *General.*—Stocking is more uneven than in second rotation areas. Stump planting has hitherto been confined to second year replacements to save unnecessary costs since sowings do well enough. It is possible that early stump-planting may, however be adopted in the future. Growth is 6 inches to 4 feet, average about 2 feet, by the first hot weather, and 6 feet to 12 feet by the second hot weather.

(*ii*) *Second Rotation Plantations*—

(*a*) *General.*—The earlier attempts at regenerating second rotation areas were not entirely successful, and the failures can probably be ascribed chiefly to faulty plantation work connected with over-frequent changes of staff. The difficulties encountered have now almost entirely disappeared.

(*b*) *Clear felling and burning.*—After clear felling a teak plantation top ends are sold in the coupe and nothing is left to burn except small branchwood and some useless species. It is considered that any possible increase in the cost of formation owing to lack of material for a good burn is much more than compensated by the revenue obtained from such sales of top ends which fetch—if my memory serves me right—about Rs. 10 to Rs. 12 per acre. The cost of clear felling and burning in second rotation plantations is much lower than in first rotation plantations being only Rs. 4-13-0 to Rs. 12-5-0. Average Rs. 7-8-0 approximately per acre.

(*c*) *Method of stocking.*—Both direct sowing and stump planting are now used—early stump planting becoming more popular each year. Stump planting at the beginning of the monsoon when tried previously gave poor results, apparently owing to excessive moisture causing the stumps to rot. This year, which was exceptionally dry, early stump planting in the first week of April was a failure, but stumps planted after the 20th April were successful. In a normal season, stump planting in the first week in April would probably be perfectly safe, but the small loss in height growth which would result from planting three weeks later is so little as to make the later and safer date of April 15th to 20th preferable. As in this year's work, a failure in the very early stump planting is cheaply insured against by providing a reserve of stumps for planting in May or June.

Costs—(*i*) *Direct sowing*—as for 1st rotation plantations.

(*ii*) *Stump planting.*—Nursery costs are not reliable but the cost appears to be about Rs. 2-4-0 per acre on the average. Cost of making crowbar holes and planting stumps is from Re. 1-0-7 to Rs. 3-11-0 per acre ; Average Rs. 2-5-2 per acre.

(*d*) *First year weeding.*—Owing to a lighter burn, weedings are more intensive in the second rotation plantations than in the first rotation plantations. The sequence is usually—

(1) A "mamooty" scraping in 4 feet wide strips in May or June—Cost Rs. 4-4-0 per acre.

(2) A weed cutting in August—Cost Re. 0-9-0 per acre.

(3) A forking in October—November in 4 feet wide strips—Cost Rs. 9-2-0 to Rs. 10-10-0 per acre (contract rate being 12 annas to 14 annas per 100 plants,)—usually the latter for this October weeding.

An alternative weeding programme proposed for 1934 plantations.

(1) A "mamooty" scraping in 1½ feet diameter circles round the plants in May or June. (Cost about Re. 0-15-0 per acre.)

(2) A scraping in 4 foot wide lines in August—Cost Rs. 4-0-0 per acre.

(3) A forking in October or November in 4 foot wide strips—Cost Rs. 9 to Rs. 11 per acre.

The total cost of first year weeding is, therefore, about Rs. 15-7-0 per acre on the average. Experiments have indicated that, as far as the growth of the teak is concerned, soil aeration by forking has no beneficial effect as compared with clean weeding without forking—at any rate as far as these West Coast areas with a heavy rainfall and moist climate are concerned. Since a forking costs more than twice as much as a scraping it is probable that weeding costs may be reduced still further by doing scrapings instead of forking in places where the type of weed growth is such that it can be effectively eradicated by scraping.

(*e*) *Replacement of casualties.*—This is usually done with entire transplants in July of the first year. It costs from about Re. 0-11-9 to Rs. 2-0-0 average about Rs. 1-3-8 per acre when part has been formed by stump planting. Most of the replacements are in the areas raised by direct sowing.

(*f*) *Second year tending.*—It is the custom to do a forking in 4 foot wide strips in May costing about Rs. 7-8-0 per acre. (It is doubtful whether this is really necessary as most of the plants are over 4 feet high and it would probably be sufficient to scrape round the backward plants that are under 2 feet high). Pruning and cutting back usually cost Re. 0-8-0 to Re. 0-15-0 average Re. 0-11-0 per acre approximately. The total second year tending cost is, therefore about Rs. 8-3-0 per acre in second rotation plantations but this could probably be reduced to about Rs. 5-8-0 per acre.

Third year tending.—Usually a climber cutting has to be done costing about Re. 0-14-0 on the average. Inspection paths are also cleared costing about Re. 0-1-6 per acre.

Summary of costs.

	First rotation.			Second rotation (by direct sowing).		
	Rs.	A.	P.	Rs.	A.	P.
Clear felling and burning	18	13	0	7	8	0
Aligning and staking	1	12	7	1	12	7
Direct sowing	1	2	9	1	2	9
Cost of seed	0	12	2	0	12	2
First year weeding	17	4	0	15	7	0
Replacements	1	13	0	1	13	0
Miscellaneous	0	12	0	0	12	0
Total first year costs	42	5	6	29	3	6
Second year weeding and tending	6	10	0	8	3	0
Third year tending	1	8	0	0	15	6
Total cost of formation	50	7	6	38	6	0 per acre.

If stump planting is done the cost of stumps and planting would be Rs. 4-9-2 instead of Rs. 1-14-11 for direct sowing but replacements would probably drop from Rs. 1-13-0 to about Re. 0-6-0 per acre making a net increase in formation cost of Rs. 1-3-3 per acre. It is very probable that this would be counterbalanced by reduced weeding costs in both first and second years.

The above figures have been obtained from the plantation registers for the last three years. As however, there has been a considerable amount of experimenting with different methods of planting and weeding, etc., they cannot be taken as accurate, but they should give a fairly correct indication of the costs. The cooly wage at Nilambur is 5 annas to 6 annas a day.

II.—*Wynaad Division*—(Begur)—

(*a*) *Locality factors*—*Rainfall* about 80 inches per annum. *Soil*—deep well drained sandy loam of gneissic origin, with black top soil rich in humus. *Type of forest*—Good quality mixed deciduous forest containing teak, *Terminalia crenulata*, *Lagerstroemia lanceolata* and *Grewia tiliaefolia* as the main species, and a good deal of *Bambusa arundinacea*.

(*b*) *General.*—Before 1930 all plantations were raised departmentally, but since that date *taungya* (locally called *tuckle*) has been gradually introduced until in 1932 and subsequently it has been possible to get the whole annual area taken up by *tuckledars*. The field crop used is *Ragi* (*Eleusine coracana*).

(*c*) *Clear felling of jungle and burning.*—Clear felling is still done departmentally the *tuckledars* being paid for it, but the cost is gradually recovered from them in subsequent works. The cost varies from Rs. 12 per acre to Rs. 22 per acre depending upon the amount of bamboos to be felled. Average cost is about Rs. 16-9-0 per acre.

(*d*) *Aligning and staking*—6 ft. × 6 ft. espacement is used. Cost from Rs. 2-10-0 per acre to Rs. 3-3-0 per acre—Average Rs. 2-15-0 per acre.

(*e*) *Method of stocking.*—Stump planting is now universally used throughout the division. Stumps are raised in thickly sown nursery beds, and the plants pulled out when one year old leaving a mass of small seedlings to grow into stumps when two years old. Much dormant seed also germinates in the second year giving fully stocked nursery beds. In this way the cost of stumps can be considerably reduced. Planting is done in crowbar holes usually from the middle to the end of April. This early planting gives a great advantage to the teak in that it gets a good start before the *ragi* crop is introduced. Soil working in patches is usually done previous to the making of crowbar holes for planting, and gives a slight but significant benefit to the teak in height growth but no noticeable difference in survivals. It is doubtful whether this soil working is worth the cost.

Cost—Nursery cost of stumps—about Rs. 4 per acre, but it should be possible to reduce this slightly.

Cost of soil working before planting—from Rs. 1-2-0 to Rs. 2-3-0 average Rs. 1-8-0 per acre.

Cost of making crowbar holes and planting stumps—from Rs. 2-8-0 to Rs. 4-11-0 per acre, Average Rs. 2-15-8 *per acre.* (The cost has been higher than the average since 1933 on account of early planting in hard dry soil.)

(*f*) *Introduction of taungya crop.*—The *tuckledars* are allotted their plots in May, usually about an acre to each family. They do a clean scraping of the area towards the end of May, and the *ragi* crop is sown at the beginning of the rains, usually in the first or second week of June. The teak is kept weeded by the *tuckledars* who also replace casualties free of cost. The *ragi* is harvested in November to early December, by which time it is 3 to 4 ft. high and very dense, completely swamping the teak, which has lost its leaves by then and is, (with late stump planting as was done till recently)—only 6 to 9 inches high. With early stump planting however, it is possible to get the plants up to over 18 inches before the *ragi* crop competes with it seriously.

First year weeding.—Usually a soil aeration is done to a diameter of 2 feet round all plants after the area is taken back from the *tuckledars* in December. *Lantana* uprootal is done from time to time the rest of the year.

Second year weeding.—A weeding is usually done just before the rains commence, special attention being given to plants less than 2 feet high. This is followed by a second weeding in August to September, backward plants usually being given a forking in 2 feet diameter circles. *Lantana* is uprooted whenever it is found. Double leaders and damaged stems are pruned back.

Third year tending—consists only in a little weeding to backward plants, *Lantana* uprootal and pruning damaged stems and double leaders.

Costs work out as follows :—(average of last three years).

	Rs.	A.	P.
Clear felling and burning	16	9	0
Aligning and staking	2	15	0
Cost of stumps (nursery charges)	4	0	0
Cost of soil working before planting	1	8	0
Making crowbar holes and planting	2	15	8
First year weeding	2	11	0
Miscellaneous	0	8	0
Total first year costs ..	31	2	8
Cost of second year weedings	6	5	0
Miscellaneous	0	7	0
Cost of third year tending	1	2	0
Total ..	40	6	8

Of this sum, the cost of clear felling and burning, Rs. 16-9-0, will be recovered partly or wholly from the *tuckledars* reducing the total cost of formation to about Rs. 34 or Rs. 35 per acre.

(*iii*) *Mount Stuart*—

(*a*) *Locality factors.*—Rainfall about 60 inches. *Soil*—a sandy loam of gneissic origin turning to clay in places. The chief feature of this locality is the very dense and vigorous weed growth, necessitating much greater care in early weedings and requiring prolonged tending into the fourth or fifth year.

(*b*) *Clear felling and burning.*—Costs have been reduced of recent years, partly due to a gregarious bamboo flowering in 1926 to 1929 which has made clear felling cheaper. A considerable amount of top ends and miscellaneous species are sold to a contractor and removed by him and this also reduces the cost. The burn is usually done in February and piling and re-burning completed by March.

(*c*) *Aligning and staking.*—Previous to 1931 the espacement was 4½ feet by 4½ ft., but since then 6 ft. × 6 ft. espacement has been tried. This has naturally reduced the cost of staking and planting but the trouble from weeds has been excessive and it appears that this wider espacement is now justified.

Sowing and planting.—Until about three years ago direct sowing in worked patches was the regular method of formation. Occasionally in good seasons good initial stocking was obtained but generally only about 35 per cent. of the stakes were stocked with plants from the original sowing and the rest were replaced by transplanting surplus seedlings from one patch to another or by notching germinating seed from dumps. In some cases, owing to replacements dying and having to be again replaced, as much as 135 per cent. to 150 per cent. of replacements were done in the first year and even then the stocking was not complete. Of recent years however, stump planting has been adopted instead of direct sowing and the introduction of early stump planting (beginning of April) has completely altered the aspect of things, it being now possible to obtain almost complete stocking from the original planting, and much better growth during the first year.

1st year weeding.—Conditions vary so much from year to year and coupe to coupe that no standard procedure is adopted.

The former practice was to go over the area six to nine times during the first year with ween cuttings and occasional mamooty scrapings in lines about 2 feet wide. In large plantations weeding was a continuous process. At present the tendency is to do fewer and more thorough scrapings in 4 foot lines, the intervening 2 feet being cut with a knife ; this is done three to five times during the first year of the plantation. Bad grassy areas are fork-weeded.

Second year weeding.—The wider espacement (6 ft. × 6 ft.) appears to affect second year weeding costs very considerably (*vide* remarks on cost statement below).

Third year and subsequent tending—this is also considerably increased in 6 ft. × 6 ft. espacement plantations as compared with 4½ ft. × 4½ ft. espacement. Plantations which appeared to be well stocked and completely established when about three years old have sometimes been badly damaged by climbers in the fourth and fifth years if left untended.

Cost.—The following statement of costs is quoted verbatim as given by Mr. M. F. Bridge, the District Forest Officer, South Coimbatore division. The two areas chosen are both normal successful plantations with which he is familiar. The average cost given in the last column is bound to be higher than normal as many of the largest plantations (1926, 1927 and 1928) had experiments with alternating strips of rosewood done throughout the area, greatly increasing weeding costs.

Costs of 1923 compared with costs of 1934.

Operation.	Cost in R. A. 1923.	Remarks.	Cost in R. A. 1934.	Remarks.	Average for last 13 years.
	Rs. A. P.		Rs. A. P.		Rs. A.
Clear felling ..	15 2 0	Standing bamboo covered large portion of area.	7 2 0	Dead bamboos, contractor removed large amount in miscellaneous species lying on the ground.	15 0
First burn ..	1 1 0	....	0 5 0	Both were successful burns. Cost depends on coolies employed to ensure safety of forest.	1 3
Piling and reburning	8 0 0	....	4 8 0	Cost of elephants employed omitted in both cases.	6 14
Aligning and staking	..	Separate figure not obtainable—cost Rs. 2-3-0 in 1924, Rs. 1-11-0 in 1925.	1 8 0	....	2 3
Dibbling teak in patches.	2 3 0	This figure includes aligning and staking.	0 8 0	This refers to dibbling rosewood and *vengai* near teak stumps.	1 12
Cost of stumps ..	..	The cost of seed is not given for these plantations.	3 1 6 per 1,000.	This figure can be reduced by using 2nd year stumps to about Rs. 2.	Average 3-2-9 last 3 years. Not included in total below.
Replacements ..	..	Costs cannot be kept separately from weeding as it is one operation.	..	As in column 13. ..	..
1st year weeding and replacements.	24 7 0	It must be borne in mind that ½ the stocking at least was got by replacement; mamooty weedings were done. Apparently 8 weedings.	11 7 0	Up to end of August and including 3 clear weedings. At most Rs. 8 more will suffice. Grass areas were forkweeded. The rest mamooty scraped together with knife cuttings.	22 2
Nursery for transplants.	0 5 0	Excluding seed	..	..	..
Total first year..	51 2 0	Cost . ..	28 7 6	Probable total for first year Rs. 35.	Average Rs. 49-2.

" These two plantations are both good but this year's is already at least 2 feet higher than 1923 was in November 1923 owing to having been planted with stumps in April instead of being dibbled in March. This should lead to cheapness in tending.

" *Second year weeding and tending.*—I must now desert my 1934 plantation as obviously it had no figures for the second year and I will take up 1932 as being next most typical of modern methods. However as it was not very well grown, figures are high in its 2nd and 3rd years. In view of the fact it was spaced 6 ft. × 6 ft. figures are instructive compared with 1923 which is 4½ × 4½ ; but it also depends on the height growth and stocking achieved in the first year.

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Operation.	1923 cost.	Remarks.	1932 cost.	Remarks.	Average.
	Rs. A. P.		Rs. A. P.		Rs. A.
Weeding including replacing casualties, Cutting back broken stems.	2 13 0	Espacement 4½′×4½′ ft. 3 weedings or tendings, Replacing casualties goes hand in hand with weeding and cannot be separately accounted for without increasing the cost.	11 7 0	Espacement 6′×6′. Considerable damage by elephants. Since 1926 this item has gone up nearly 100 per cent. It may have something to do with bamboo flowering and consequent spread of weeds, grass and *Lantana*. The experiment of trying alternate rows of rosewood for some years must have helped the weeds.	5 15
		3rd year tending.			
Tending	0 13 0	Rs. 3-5-0 has been spent and it is estimated that Rs. 5 will be required per acre in all this year and S. O. is passed. Main items are cutting back damaged stems and creepers and soil working with forks round backward plants in grassy areas.	..	....	1 14

" I think experience points to the fact that more tending is required than has been given in the past and that it is unsafe ever to assume a plantation is established.

" Between 1923 and 1934—certain changes in conditions have occurred which affect the work under consideration.

(*a*) Bamboo flowered about 1929. Bamboo is costly to cut out of the area and clear felling is now less expensive but weeds of all sorts have increased greatly since it died.

(*b*) Espacement is now 6 ft. × 6 ft. instead of 4½ ft. × 4½ ft. The results in 1933 and 1932 do not justify the change and the trouble from weeds has been excessive.

(*c*) Local labour is obtainable in greater quantities and it is good and cheaper than imported labour.

" Finally, the greatest bit of ' technique ' to be had in raising a plantation is a keen Ranger with organising ability and control of labour. Here is a variable factor which may influence costs 50 per cent. and results even more.

" My impression after an absence of 10 years from this district is that tending in the 4th and 5th years has been neglected. Plantations I thought fully established show great deterioration for want of continual attention. It appears that some attention is required between the first and second thinnings as damage by creepers, *Lantana* and other species such as *venteak* (*Lagerstroemia lanceolata*) during this period does great and permanent injury to plantations.

With early planting of stumps (beginning of April) and skill and care by the Range Officer a first rate plantation should be assured in the 1st year for Rs. 40 to Rs. 36. About Rs. 2 a year will be needed until the first t

" These remarks apply only to this area which is the home of weeds, creepers, Mr. Bridge finally lays emphasis on the doctrine preached by the late Mr. Hugo Wood, Conservator in this Presidency namely " see it done yourself ". Mr. Wood used to insist on his District Forest Officer's camping right on the spot and there is no doubt that the success of many of the earlier plantations done during his regime was due to the close personal supervision, that was given to them by the District Forest Officers.

During the last four years attempts have been made at introducing a mixture in teak plantation by dibbling rosewood seed at the same stake as the teak. This matter is dealt with more fully under Item 23.

PAPER (*iii*).

By E. A. GARLAND, *Working Plan Officer, Southern Circle, Bombay.*

Teak plantation work in the Bombay Presidency may be considered as passing through three stages, or phases. At first it was confined exclusively to nurseries or " gardens ". The sites for these were often selected apparently rather more with regard to accessibility, near a bungalow or road, than on consideration of the suitability of soil or climate for the particular species with which experiments were to be made. Views upon how environment reacted upon the growth of different tree species appear to have been generally meagre or confused. The work was carried on more as a form of gardening than as forestry and costs were generally entirely out of proportion to results, from a commercial point of view. At this time practically the only form of artificial regeneration, attempted actually in the forests themselves, was by broadcasting many tons of teak seed over the bare hill sides of the Deccan in an attempt to restore forest in places from which it had disappeared probably very many years previously, and where subsequent exposure and continual erosion had utterly impoverished what little soil still remained. As may be imagined the results were not highly gratifying. Valuable experience was however gradually accumulated as to where and how teak would, or would not, grow satisfactorily even though the reasons for this were still only partially understood. The nursery work was also useful chiefly through the associated experiments with regard to the germination of teak seed. As early as 1870 Major W. Peyton, Conservator of the Southern Circle, recorded his experiences in this matter in Kanara. He states that the rule then generally recognised was putting the seed into nearly boiling water for several hours previous to sowing and thereafter watering for 18 to 25 days ; a method which he says resulted in repeated failures. Instead he advocated careful preparation of the seed bed. This was first to be turned up in big clods, these broken with a mallet, and then a liberal mixture of fine forest mould added. Carefully selected fresh seed should then be sown, and covered with not more than 2 inches of fine mould. No effort was to be made to encourage the seed to germinate during the first monsoon season, nor were the beds to be disturbed at all, grass and rubbish being allowed to grow up on them and accumulate. " A fortnight or 3 weeks before the setting in of the next rains, the beds, with the addition of dry grass, bamboos and rubbish, should be well fired, and after being loosened with a pick, watered freely for a couple or three days, when an almost simultaneous germination will be found to take place ". The same author recommended an alternative method quicker than the above but not likely to produce more than 25 per cent. germination. In this the seeds beds were to be broken into big clods as before, but before breaking up the clods, they should be covered with dry bamboos, grass and rubbish, so as to almost bake the clods when burnt. The beds should then be prepared and seed sown, so as only just to be covered with the ashes. Germination would then take place after the first few showers of rain without any preliminary watering.

The second stage in teak plantation technique commenced when nursery experience was gradually taken out for practice into the forests. The plants were raised in central nurseries and transplanted into small pits which had been previously well dug up. Direct sowing was seldom attempted. But the success of these operations was rather limited, partly on account of the considerable distances which the plants often had to be conveyed, but chiefly because they were not as a rule utilised to replace forest which had been exploited, but in order to try to establish a crop of teak on sites until then, to a greater or lesser degree, bare of tree growth. The principle appears to have been that where a full forest crop had already existed natural regeneration, either from seed or coppice, would adequately replace it again after exploitation. The fact that the almost invariable methods of management at this time were either the Indian Selection System or Coppice with Standards doubtless encouraged this line of thought. But in addition it seems that so long as the soil appeared adequate the absence, or unsatisfactory growth, of trees on any particular site was regarded as due rather to lack of opportunity, or past mismanagement, than as being the consequence of some inherent unsuitability of the soil, or the climatic conditions. Sometimes, as for instance where bamboo growth had previously smothered all regeneration and had then died, successful small plantations were raised. But frequently even a satisfactory start was followed by subsequent stagnation and the young plants, in spite of every attention, never throve sufficiently to produce marketable timber. Such failures led to further experiments in the treatment of seed and to comparisons between direct sowings and transplants, for the acceleration of growth in the first season so that the young seedlings might the better overcome competition from weeds and grasses. It was this consideration of reducing adverse competition from weeds which orginally led to the adoption of the method of burning slashwood and debris collected on the plantation site, which seems to have been started originally in Kanara, and taken thence to Thana, until finally it has spread throughout the Presidency. The patches so treated were at first quite small, being usually openings caused by Selection fellings. But gradually, when clear-felling superseded the Selection system, the operation became extended on to a larger scale. In Kanara, the forest crops being heavy under favourable climatic conditions, and only a small proportion of the trees being saleable, wholesale burning of the large quantity of refuse, frequently including plenty of bamboos, would be done over considerable areas. These might be anything from 10 to 70 or 100 acres, which had been clearfelled and on which the previous mixed crop was replaced by pure teak. But in the drier zones where the forests were more open, bamboos generally scarce or absence, and the trees growing to little beyond pole size, but where frequently the proportion of teak in the crop was much greater, only relatively small patches would be selected throughout the clear-felled area. These would be piled with all available brushwood, burnt, and artificially regenerated with teak, while the remainder of the clear-felled coupe was left to regenerate itself naturally from seed, or by coppice shoots, of mixed species. Similar restrictions occurred in most of the Thana forests, though here the crops were generally heavier : the cause of deficient material for burning being that so much was removed by the purchasers. Owing to the proximity of Bombay, almost anything unsuitable for timber was marketable as firewood, or converted into charcoal, and even the smallest branchwood was removed by the local villagers, who have the privilege of taking anything under 6 in. in girth. The sites of the charcoal kilns however proved to be suitable for raising teak after the ash had been removed. In all the areas where the plantation work was concentrated on small patches there was a natural incentive to raise teak too close, say 2 ft. × 2 ft., and to be too reluctant to thin out early and ruthlessly ; the latter being also partly due to the difficulty of finding many of these small patches in the thicket of quick-growing xerophytic species which spring up in the first few years after a clear-felling. In consequence, in recent years, there has been a steady change to making the patches larger, and therefore fewer in number in each annual coupe. This change has also been encouraged by another consideration, namely the choice of only those sites which are the most suitable out of the area available for plantation work. In Kanara this same cause has led to rather different results, it having been found generally impossible to obtain a compact area of 100, or even 50, acres all of which can be considered really suitable. The tendency there has been consequently to make the individual plantations rather smaller, or to omit the unsuitable portions and to make the plantations, though continuous, of more irregular shape. It is this interest in sites, or "habitats", for which the great advances in soil science and ecology are doubtless responsible, which the writer regards as marking the commencement of the 3rd stage in teak plantation technique in Bombay. Formerly attention had been chiefly concentrated upon the actual seed, its germination, and the early growth of the seedling until fully established as a sapling. To this is now added the realisation of the importance of its environment and of the interplay of all the multitudinous factors which react upon its growth. It is also realised that the beneficial results of burning are not so much through the reduction of adverse plant competition, or even through the direct manurial value of the addition of the wood ash, as through the extremely complicated modifications of the actual soil constituents and population.

It may be preferable first to summarise briefly the present position and then to sketch in the lines upon which further developments may be expected to occur.

Preparation of the site.—Careful heaping and burning of branchwood and refuse is now the invariable practice. Where large logs are included in the refuse, heaping a second time and burning again is often necessary.

)f plantations.—This varies with the amount of branchwood and refuse available for burning, which in turn is controlled chiefly by climatic conditions, but also in some districts (notably Thana) by market demand. The same causes also influence the proportion of plantation, which may be in small or large patches, to the total coupe area. In the Panch Mahals district, where conditions are probably as arid as any in which teak can be grown with reasonable success, the individual patches are usually 40 ft. × 40 ft., and a total of only 3 to 5 acres, out of each 100 acres of coupe, is planted. In Thana district the size of each plantation patch is now not less than 40 ft. × 40 ft. and may be 80 ft. × 80 ft. or more. In the Dangs they are usually 50 ft. × 50 ft. and in West Nasik division 1 square chain. In Kanara half an acre is taken as the absolute minimum and continuous plantations may be made up to about 30 acres conditions are favourable.

Treatment of seed and method of formation.—The usual method of treating the seed prior to sowing is to collect it one year in advance and to " weather " it by spreading out on boards or flat rocks and allowing it to be thoroughly soaked by the rain of the first monsoon. Where the rainfall is light (30 in. or less) this weathering is done throughout the monsoon but under conditions of heavy rainfall the seed will not be put out before July. After having been weathered, the seed is thoroughly dried, carefully sorted, and stored until required for sowing in the following April before the break of the second monsoon. If for any reason seed of the previous year is deficient, that of the current year can be treated with a fair measure of success by alternately soaking for 8 to 12 days and then drying for a similar period ; the process being repeated twice or three. Formerly direct sowings were the general rules, failures being replaced by seedling transplants. As these seedlings were transplanted with entire root systems, and a little earth, they had to be quite small. The measure of success was frequently very variable. Direct sowing has now been entirely superseded in the Southern Circle, and is gradually disappearing throughout the Presidency. Instead seed, similarly treated, is sown broadcast in nursery beds. The seedlings are later pricked out to a spacing of 6 in × 6 in. and kept until the following year when they are " stumped " and planted out in April. " Stumping " consists of cutting back the plant to from 1 to 1½ inches of collar and 6½ to 7 inches of root. These stumps are planted at an angle of about 45° and half an inch below ground level. They successfully survive periods of excessive or deficient rainfall during the monsoon which would kill almost all little first-year seedlings. The general rule now is to make nurseries for next year's stumps in the current year's coupe. These are dry nurseries, overhead shade being provided in the hot weather where necessary. In some cases, where suitable sites are available near water, wet nurseries of a semi-permanent nature are established as a reserve. The object in all cases is to have always on hand an ample supply of 1 year old seedlings suitable for stumping to replace casualties later in the monsoon season, as well as to stock the plantations on formation.

Spacing.—Spacing in plantations is now almost invariably 6 ft. × 6 ft., the only important exceptions being Northern Kanara where the spacing is either 12 ft. × 6 ft. or 9 ft. × 9 ft. and Panch Mahals where it is still 3 ft. × 3 ft.

Tending after formation.—As a general rule plantations are weeded 3 times in their year of formation, twice in the 2nd year and once in the 3rd year. Exceptions are of course made where inspections show that unusually dense growth of weeds, or especially of creepers, necessitates additional attention. In the drier zones it is frequently possible to reduce the numbers of weedings required. Stumps usually develop two or more shoots. Surplus shoots, therefore, have to be carefully cut off when about 3 to 4 inches high, leaving only one to grow on. At the same time the surrounding soil is well aerated. Later the plants are earthed up when about 9 inches tall. In especially dry districts this earthing up is elaborated to take the form of a mulch, grass being mixed with earth, with the idea of reducing evaporation owing to the soil packing. Badly developed saplings are cleaned out in the 5th year. Of growth of species other than teak which has sprung up between the lines, only such is cut back which is definitely liable to interfere with the teak, the remainder being kept for soil cover. In some places in Eastern Kanara sowings of *Tephrosia candida* between the teak lines have proved to be a quite successful alternative. After their 5th year the plantations are carefully watched by annual inspections, subsequent cleanings and cutting of creepers is done whenever required, and the first thinning of the teak made when necessary. This is usually about the 15th year, but may frequently be earlier where the growth is good. The present tendency is definitely towards earlier opening up of the teak than was formerly practised, though no hard and fast decision has yet been made in this matter, the optimum spacing relative to height growth being still under study in series of sample plots. The objective is to open up the teak sufficiently to allow a self-sown under-storey of other species to develop, and yet not to sacrifice more young teak poles, at a size when they are still not marketable, than is absolutely necessary to obtain this under-storey. The latter is now generally considered to be essential to the subsequent proper development of the teak. Underplanting with particular species, for which a good sale might be anticipated, has been abandoned as unsatisfactory. No such species have yet been found which combine well with teak. Either they become too strongly dominant (*e.g.*, *Gmelina arborea*) or else are suppressed. The under-storey of self-sown species is regarded purely as necessary soil cover, which can be lopped, or pollarded, or cut out, directly it shows any tendency to interfere with the teak.

Costs.—In districts where the coupes are sold standing a large proportion of the cost of laying the branchwood ready for burning is hidden in work carried out by the purchasers of the coupes. A variable proportion of the subsequent work of burning, sowing, planting and weeding is also done by the permanent staff. It has not been possible to obtain any figures which can be relied upon to include all such hidden costs. A fair estimate however may be—

	Rs.
Heaping, burning and reburning branchwood and refuse	8 to 12
Nurseries and seed	2|8 to 3
Planting and weeding	8 to 12

Or an average of about Rs. 25 per acre of actual plantation. To this must be added the cost of felling unsaleable timber standing on the site. In Thana district this will be almost negligible but in Kanara it amounts to between Rs. 25 and Rs. 30 per acre. Other districts will be intermediate between these two extremes. Taungya is hardly practised at all except in the Kolaba district. The effect on costs is to eliminate most of the charges for planting and weeding.

Attention is now being concentrated upon the justification for the heavy costs, whether actual or hidden, involved in the method of preparing the plantation sites by heaping and burning branchwood, and suggestions are being made that other methods might be equally, or more, effective, at a smaller, or similar cost. The precise action of such partial sterilisation of the soil is still not yet definitely decided by soil scientists. The hypothesis, of Russell and Hutchinson, that destruction of the protozoa in the soil permits the accelerated development of bacteria, is apparently not accepted as fully explaining all the numerous changes which occur. It is however generally conceded that soil rich in a great variety of organic constituents respond best to such treatment. This certainly coincides with our experience. The method started in the Kanara forests, where the climatic conditions of equable temperature and heavy rainfall result in a climax forest of evergreen, which evidently supplies very large quantities of organic material to the soil. On the other hand much of our teak grows under conditions of climate which must result in very different soil conditions. The difference will be not only in the chemical and physical characteristics of the organic and inorganic soil material, but also in the nature of the soil population, especially quantitive distribution. It is significant that the agriculturist with his centuries of accumulated experience, has evolved a markedly different technique in the preparation of the soil for his field crops. In the zone of heavy rainfall he prepares his seed bed by precisely the same method of heaping and burning brushwood (" *rab* ") and ploughs up his fields only shortly before the arrival of the monsoon. May this practice perhaps permit undisturbed development of algae ? In the zone of lower rainfall the land is ploughed up immediately the crop is lifted off it, *i.e.*, in December and January, and the soil is left, broken thus into large clods, to the action of sun and air. This alone apparently suffices to restore a reasonable degree of fertility, though often farm manure is added. But burning of brushwood is not practised for the preparation of a seed bed, even where there is an ample supply of material available close at hand. As in so many other matters, is it not probable that ordinary agricultural practice may point the way for scientific investigations to evolve a modification of our technique ?

PAPER (IV).

By H. C. Watts, *Silviculturist, Central Provinces.*

Most of the teak forests of the Central Provinces are of poor quality and the selling price per acre, even under a clear felling system, rarely exceeds Rs. 20 to Rs. 30 per acre. Expenditure on artificial teak regeneration, except on an experimental scale, can probably therefore only be justified in places where the soil and drainage are sufficiently favourable to render it probable that teak is likely to attain at least C. P. III quality (50′—70′ at maturity). For these reasons, few plantations have been raised during the 30 years period 1900 to 1930 and these plantations were on little more than an experimental scale.

It is only during the last four years that important teak plantation work has been undertaken. Under the prescriptions of the Bilaspur working plan, approximately 30 acres a year have been very successfully planted during the past four years, the system adopted being that locally known as the *dona* (or leaf cup) system, originated by Mr. Lokre, the distinctive feature of which is that germinating seedlings are pricked out in April into small cups made of woven leaves. The seedlings are allowed to grow in these cups until the rains break, when the cups are themselves transplanted to the plantation area. In this way the young plants are subjected to the minimum of shock in transplanting. The system has given an extraordinarily high percentage of success and a more detailed account of it is submitted.

The South Chanda teak forests are among the most valuable teak forests of the Central Provinces. A plan prescribing conversion to even-aged forest was introduced six years ago but natural reproduction has been unsatisfactory and artificial methods, chiefly stump planting, have been resorted to on a large scale. 150 acres were successfully planted in 1933, 200 acres are being undertaken this year, and it is proposed to plant up 300 acres next year. These are by far the most ambitious plantations ever attempted in the Central Provinces and a descriptive note written by Mr. Tasdiq Hussain, I. F. S., is submitted.

The soil in both these divisions is chiefly quartz schist or gneiss. Rainfall averages 50″ to 60″. The forests are chiefly of C. P. III quality (50′—70′) but occasionally II quality (70′—90′). Teak attains maturity at about 5 ft. girth, trees over this size seldom being sound.

Bilaspur.—The 'Dona' or leaf-cup system.

1. *General.*—Teak plantations have been undertaken during the last five years in the Bilaspur division, in which the forests are chiefly mixed forests with only scattered teak. The soil is usually schist. Only well stocked areas of C. P. III quality (50′—70′) are considered suitable for planting ; IV quality mixed forest (below 50′) is the prevailing type in this division and indeed over very large tracts in the Central Provinces ; but in Bilaspur it is considered that such forests are not capable of producing teak of sufficiently high quality to justify expenditure on teak plantations. No attempt is, therefore, made to form plantations in IV quality areas or in blanks. The teak plantations are generally most successful in forests where the previous crop consisted of good quality mixed forest with an understorey of bamboo.

2. *Preparation of site.*—All saleable timber is first felled and removed from the area as early as possible in the working season. The unsaleable material is then clear felled, all undergrowth being first cut back : as soon as this material is moderately dry, it is burnt, so as to clean the site by reducing to ashes all grass, twigs and the smaller refuse. The larger material will mostly be left unburnt, but the site will be sufficiently cleared for laying out and marking the planting positions. For demarcation, a Gunter's chain is

used and a spacing of 6.6 ft. (10 links) adopted. Such spacing makes laying out with a chain easy and requires exactly 1000 plants to the acre. Pegging the position for each plant is found unnecessary ; the position is merely marked with a few strokes of a pick-axe, while the chain is stretched, and it is found that the marks remain visible until the plants are put out early in the rains. Large pits are not dug, but small pits, the size of the *dona* or leaf cup (4" diameter and 4" deep) are made at the time of planting, when the soil has been softened by rain. After the planting sites have been marked, the unburnt wood is cut up, and heaped evenly at each site. The heaps are fired a few days before the first showers are expected in June : earlier burning would result in the ashes being blown away. It is found that this second firing greatly reduces the expenditure on weeding and the cost of logging is thus more than repaid.

3. *Collection of seed and preparation of donas.*—The seed is collected locally, as far as possible from specially selected marked trees ; but Mysore and Nilambur seed gives the best results in Bilaspur. The *donas* or leaf cups, are made of tough old leaves, young leaves being useless for the purpose, as they would rot in a few days. *Palas* (*Butea frondosa*) and small teak leaves are found most suitable and these are collected and stored during the winter. When the *donas* are prepared the leaves must first be moistened. A *dona* requires about four leaves and is about 3 to 4 inches deep, 3 inches across at the top and 4 inches at the bottom. Thin bamboo splints are used to fasten the leaves together, and the leaves are doubled in every part of the *dona*. Women and children can do this work and a dona can be made in about half a minute : the cost is therefore not great. Before filling with earth, the *dona* is perforated at the bottom to allow drainage of water. The earth used in the *dona* is powdered and sifted and strengthened by the addition of leaf mould and cow manure. The proportion used is 4 parts earth, one part leaf mould and one part manure.

4. *Sowing in the donas.*—Weathered teak seed is sown or spread in beds in a nursery about the middle of April and watered daily : as soon as germination starts, the germinating seeds in which the radicle or the cotyledons have begun to appear are gently picked out and planted in the *donas,* one in each *dona.* It is in the *dona* itself that the radicle enters the soil and the cotyledons are first exposed : as the *donas* are filled with the seedlings they are placed on racks of bamboo *tattas* resting on cross pieces of 18" girth and thus raised about 6 inches above ground level. The *donas* must on no account be placed on the ground where the tap root would penetrate the *dona* and enter the soil. A *tatta* 40 feet long and 4 feet wide can carry 1,000 *donas.* To regulate transpiration, grass screens 7 feet high and 4 inches thick are erected all round the site where the donas are kept, in order to break the force of winds, and in very hot weather overhead shelter is also provided against excessive sun by erecting over the beds bamboo screens so woven as to break the strength of the sun but not completely to exclude it. This overhead shade is removed as soon as the weather becomes cloudy or the plants are sufficiently strong and in any case must be removed by the middle of June. In very hot weather the ground and the grass screens surrounding the plot are watered, to reduce transpiration. The *dona* plants themselves are watered at least once a day, a watering can with a fine rose being used.

5. *Transplanting.*—The plants continue to grow in the *dona* for 6 or 8 weeks until the rains break, when the height should be about 6 to 8 inches. As soon as the rains break the *donas* are carried to the plantation site, the leaves of the *dona* torn off, and the plants put out into pits of the same size as the *donas* themselves. The great advantages of this system appear to be that the plants are subjected to little or no disturbance at the time of transplanting, which is an exceedingly simple operation. They are already 6 or 8 inches high when planted out, and thus have obtained a start against competing weeds.

6. *Weedings.*—Grass and weeds are pulled out by hand as soon as they have grown sufficiently high to make this possible. Coppice shoots and seedlings of inferior species and bamboos are cut only when actually interfering or likely soon to interfere with the teak seedlings.

7. *Costs.*—Average total costs, including weeding, have been about Rs. 14 per acre. This is more than double the South Chanda costs, but the spacing has been 6' × 6' compared with 12' × 12' or 15' × 15'.

Note by Mr. Tasdiq Hussain, I.F.S., on planting and nursery work in the Allapilli Range of the South Chanda division during 1934.

This note summarises preliminary work done during the hot weather, 1934, and the work done at the commencement of rains. The programme of work for this year included :—

(1) Planting of about 200 acres in compartment 33.

(2) Replacement of casualties in last year's planting area.

(3) Raising about 80,000 seedlings in the nursery at Talwara for use next year.

Compartment No. 33.—The *semal* in the coupe was sold standing to a contractor who did not vacate the coupe till the middle of May, thus delaying the preliminary work. All other species including bamboos were clear felled departmentally by the end of March. The coupe was burnt on the 17th May. The fire was not sufficiently severe and in places even bamboos and thinner branches were not burnt. These were collected in heaps and reburnt and the bigger logs dragged into *nalas* by elephants. These operations were completed over about 70 acres only as the rains broke and firing became impossible. There was no time for either staking or pit digging and this work had to be carried out at the time of planting : staking is essential but in South Chanda the digging of pits is not necessary.

Planting started on the 20th June. About 5 acres were planted with *semal donas* (leaf cup-plants) and about 3 acres with teak *donas.* The rest of the area was planted with teak root and shoot cuttings. These were obtained from one-year-old nursery plants. Several thousand plants which had roots too thin for putting out as stumps were transplanted with the root system, as far as possible, intact : these mostly failed. All the nursery plants put out as stumps or transplants were from the local seed. The teak *donas* were from seed obtained from Nilambur.

Over about 130 acres the spacing was the same as last year, namely 12′ × 12′. Over the rest of the area spacing was increased to 15′ × 15′ as the total number of plants in the nursery was about 60,000 and at least 20,000 plants had to be reserved for replacing casualties in compartment 32-A and 33. 10,000 teak *donas* had been got ready in view of this shortage but they were made a little too late in the season and new *palas* (*Butea frondosa*) leaves had to be used so that not only were the plants not big enough but the transport in carts to the coupe resulted in heavy casualties. Carrying in *kawars* was tried but the *donas* this year were too big and only 10—12 could be carried in two baskets : only 500 *donas* were put out. The *dona* technique this year was in accordance with Mr. Lokre's note but the work was started late. Seed was put out and watered and directly the radicle appeared the seed was transferred to the *dona* cups. Unfortunately it was not foreseen early enough in the season that *donas* would be required. Old leaves had not been collected, and the seed was not put out to germinate until about the second week of May.

The technique of stump planting was the standard technique for this work and need not be described. The work was simple as nursery plants were available. The weather conditions were also ideal. Except in the last week it rained during the night while the weather during the day was cloudy. Planting started on the 20th June and was completed on the 3rd July, notwithstanding some difficulty about tools and although staking had to be done at the time of planting. Much *kawitch* (*Mucuna pruriens*) came up after the first few showers and was eradicated. Weeds were coming up fast when the coupe was inspected on the 6th July and a weeding has since been carried out. About 95 per cent. of the cuttings had already sprouted and those put out on the first day had 4—6 leaves. Casualties will be replaced at the time of weeding and about 6,000 plants have been reserved for this purpose.

Semal donas were put out in two alluvial patches but these also were prepared rather late. Seed was sown direct into *donas.* It germinated within 6 days and the plants were put out about one week after germinating. The seed might just as well have been sown direct in the coupe as percentage of germination is high.

Compartment No. 32-A (1933 plantation).—This compartment was taken up after compartment 33. By the 7th of July, 12,000 casualties had been replaced over about 130 acres : last year's spacing was 12′ × 12′ and about 7C per cent. of the plants put out last year have survived. Many plants died back but came up again with the rains, and the success of the work in this coupe is assured. The smaller plants are being weeded and overhanging bamboos are being cut over all the plantation. Casualties are all being replaced with stumps or transplants : as the weather conditions were favourable, the transplants are doing well.

Nursery.—A new site was cleared during the hot weather. The beds were thoroughly worked to allow the roots to penetrate the soil without forking. Last year when the site was cleared and the beds were prepared in July, the teak plants were badly grown, the tap root having branched superficially. The beds were manured with ashes.

The seed available was this year's local seed, last year's weathered seed, and about 800 lbs. of unweathered Nilambur seed. Weathered seed was sown direct in several beds in lines 6″ apart. Local and Nilambur unweathered seed and some weathered seed was spread out thickly on beds at intervals of 5 beds the intention being to prick out the germinating seedlings into the adjoining beds.

The weathered seed germinated excellently, giving almost complete lines and the unweathered seed was also germinating by 6th July. It was expected that germination would be later as the beds had not been watered and the rains did not start before June 20th. The Nilambur seed put out for *donas* in the middle of May and regularly watered, germinated profusely within a fortnight. Pricking out started about the 1st July and over 90,000 plants were pricked out. The nursery practice has now been more or less standardised and the recurring expenditure on the nursery will be negligible. The expenditure on pricking out this year was about Rs. 20.

Suggestions for future work.

Plantation.—The following planting programme should be adhered to as far as possible :—

1. The coupe should be clearfelled by the end of February.

2. *Semal* should not be sold to a contractor, as his presence in the coupe interferes with preliminary plantation work.

3. The coupe should be burnt towards the end of April.

4. The unburnt material should again be collected and burnt in heaps and the coupe finally cleared by the third week of May.

5. It is essential to stake the area in advance between the last week of May and the start of the rains. Staking takes as much time as the actual planting. If the area is staked in advance it is possible to plant 40 acres a day with about 120 coolies.

There is a general tendency for subordinates to attempt to put in stakes in straight lines. As we are raising a forest plantation and not a park, as as the stakes are 12′ by 12′, precision is unnecessary.

6. Advance digging of pits is unnecessary. The pits get easily choked and have to be redug. Pit digging is most economically carried out at the time of planting.

7. Stumps must be at least ½″ in diameter : otherwise they fail.

Nursery.

1. The beds from which plants have been removed should be allowed to weather till well after the rains when they should be levelled up and manured with wood ashes and weathered cow dung.

2. Weathered seed should be thickly sown direct into beds in lines.

3. Unweathered seed should be spread out at intervals in the nursery. Germination of this seed is irregular, excepting of Nilambur seed, which germinates well.

4. No watering is necessary. Seed should be sown in beds or put out for germinating towards the end of May.

1. The following tools, etc., are required for 100 acres of plantation :—

Pickaxes	30
Shovels	30
Crowbars	50
Axes	30
Machets	2
Baskets	20

The average nursery and planting daily tasks for a cooly are given below. These averages are based on the actuals of this planting season :—

Nature of task.	*Quantity or No. a cooly can do daily.*
Digging stumps from the nursery	150—200 according to size.
Putting out stumps in the plantation	100, including digging pits at the time of planting.
Staking, including cutting of and carrying of stakes from the forest.	80 coolies completed about 60 acres with a spacing of 15′ × 15′.
Pricking out seedlings in nursery beds	800

The average cost of the actual planting including staking this year was about Rs. 1-8-0 per acre (excluding nursery work). The total cost of labour including nursery work is under Rs. 5 per acre.

Addendum by Mr. C. M. Harlow.—A great want that I feel and which I think must be felt by others is a text book of some kind on the silviculture of teak, particularly with reference to its regeneration both natural and artificial. Whenever any question arises one at once realises that there is nowhere authoritative book that one can look for an answer except Troup's silviculture which is quite out of date as regards teak.

I take it for granted that the need for such a text book will be everywhere admitted and the form of discussion at the Conference should be regarding the lines on which the question is to be tackled. For many reasons it would be desirable to have all information from all provinces in one volume but possibly such a work would become unwieldy in size. On the other hand certain provinces might prefer to produce their own work primarily for their own use. The important matter from the Divisional Officer's point of view is to have a book of reference from which all the up-to-date information will be available. What we want in the Central Provinces for example is information in a handy form about the methods employed for artificial regeneration of teak in Nilambur, in Burma, the Bombay *rab* methods, the Gorakhpur methods, the North Raipur methods, etc. Then there is the ever-recurring question of the treatment of teak seed, the need of weeding, the effect of late weeding. We lose a lot now by having to learn by our own mistakes which could be avoided if we had a reliable text-book, kept up-to-date by re-editions at reasonable intervals.

I suggest then for discussion the form in which such a book or books are to be produced and the agency of production.

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PAPER (V).

By C. K. HOMFRAY, *Silviculturist, Bengal.*

Chittagong Hill Tracts is the only division where teak is being put out systematically on a large scale and these notes refer to that division only. The method employed is '*taungya*' and there are no departmental *taungyas* of *teak*.

Soil.—The soil varies from clay to clayey loam on level ground to sandy loam over sandstone on the slopes. Humus is absent. The clayey level ground is to be found near the banks of streams and is often water-logged, and *teak* is confined to the slopes only where the growth is best.

Climate.—The temperatures are high and the humidity great. The cold season is short, there are no great extremes of temperature but very heavy dews occur at night. The rainfall is heavy, the yearly average being over 100″. The heaviest rainfall is between June and September, but storms occur from March onwards and there is seldom a month in the year with no rain at all. From the beginning of May there is usually no long period of drought and it is safe to sow seeds.

Teak seeds are collected in January-February locally from trees of the older plantations. Seeds are collected from the ground. After collection—seeds are dried in the sun for 6 or 7 days and stored until April-May. The *jhums* are clear-felled, and burnt early in April and staking is done 6′ × 6′ Before sowing in April-May, teak seeds are treated under the pit method as follows :—

A pit is dug two or three feet deep and three to four feet square and filled with water. When this has run out—the bottom and sides of the pit are lined with teak leaves. The seeds are soaked for 48 hours in water in a tub warmed by the sun during the day, and then put in the pit with a layer of teak leaves between the layers of seeds and a final cover of 6″ of earth. Before filling up the pit in this manner 5 bamboo pipes, one in the middle and one at each corner, the latter laid at a slant, are put in to position and holes cut in them, so that when the pit has been filled up water can reach all layers. The seeds are kept in the pit for about 10 days and watering is done every alternate day. The pit is then opened and normally about 10 per cent. of seeds are expected to have germinated. Heavy watering must not be done. Successful treatment of seed is a very important item and must be done by a reliable hand.

After the above treatment seeds are sown direct within at least two days of removal from the pit in *thalis* 6′ × 6′, 4 to 6 seeds per *thali* ; for this about 25 lbs. of seeds are required per acre. Seeds are sown in April-May and there is no need to wait for the break of the rains. Seeds are sown ½″ below the ground. Germination takes place within a week and is complete within two months, the percentage of success in terms of stakes should be between 60 and 70 with good supervision. Small nurseries are sown up with seeds on each man's *jhum* to act as a reserve of transplants to fill up vacancies by transplanting in the first year and by stump planting in the second. This method used to completely stock the areas in 2 years and was employed up to the year 1931.

In 1931 it was thought that a considerable amount of infilling had to be done in the second year in plantations raised by direct sowing. To obviate this it was decided in 1932 to transplant all over the area instead of direct sowing, on the lines recommended by Blanford in Burma Forest Bulletin No. 24—Silvicultural Series, No. 14—published in 1931. Seedlings used were from 4″ to 6″ high instead of those that had just put out these cotyledons as suggested by Blanford. The *Jhumias* were supplied with sufficient quantities of pit treated seeds in April-May which were sown in temporary nurseries in their respective *jhums*. Transplanting of healthy seedlings 4″—6″ in height was started after the rains were known to have set in and continued until the area was complete taking advantage of spells of wet weather. Experience has shown that seeds should not be sown too early or the plants become too big. Transplanting must not be done until the real monsoon starts towards the end of June so as to avoid any spell of drought after transplanting.

This method was carried out in 1932 and 1933. It was found that trans- took much longer than direct sowing and in consequence the cleaning of the 2nd year and older plantations was delayed considerably and a certain amount of damage was done by *assam lota* (*Eupatorium odoratum*) in these plantations, whereas as direct sowing is completed by the middle of May and paddy sown by the end of June leaving labour available for cleaning in the older plantations in July. There was also the danger of drought directly after transplanting and considerable infilling had to be done in the first year. The growth of the plants that were transplanted early was better than the average from direct sowing but the height growth of the resulting crop was found to be patchy owing to infillings. Taking all things together it was felt that no appreciable increase in stocking and growth was obtained in the first year by transplanting, and that as it took longer to complete than direct sowing, cleanings in the 2nd year and older plantations were delayed and damage by *assam lota* was likely to be considerable. Also owing to the labour involved in transplanting it was felt that the interest of the *jhumias* were being completely subordinated to those of the department and this is hardly fair provided success can be obtained without interfering with their legitimate requirements. Sowing can be completed by the middle of May before the *jhumia* has to think of sowing his paddy, whereas transplanting cannot be done without risk before the end of June at which time he should be putting out his paddy. Excellent plantations have been raised by direct sowing, which method suits the *jhumia.*

In the meanwhile in 1932 the Provincial Silviculturist had written to the Burma Silviculturist regarding the methods in force in Burma after the issue of Blanford's Bulletin in 1931 and got the following reply :—

" *Subject.*—Sowing teak direct in plantations. The sowing of teak in plantations has not been given up and remains the normal method of regeneration in most divisions in Burma, though generally germinating seeds are used. The seed is sown as soon as the *taungya* has been burnt in small quantities on numerous small patches and as soon as the *taungya* has been staked and the seeds have started germination the seedlings are transferred to stake.

In the Hlaing Circle it appears that some experiments were carried out with small transplants from nurseries of the year, *i.e.*, aged 1 to 2 months. It seems that this method was no improvement on the general method. The Divisional Forest Officer, Prome division's report is as follows—" Transplanting of teak seedlings was done as the Conservator expressed himself very strongly in favour of this method. The villagers, however, distrusted the innovation and sowed seed at each stake as well as transplanting. The result has been that there are 3 or 4 seedlings at each stake in many places. There is no difference of growth so that it is quite impossible to tell transplants from seedlings. It would appear that in this area transplanting is so much extra work for nothing ".

In the Myitkyina division teak stumps are always used because the germination of teak seed is slow and uncertain. The nursery treatment is of the simplest kind. Beds are dug up 6" deep and the soil is raised a few inches.

The seed is sown fairly thickly as soon as possible after collection. The plants from which the stumps are obtained are just over 1 year old when put out.

Consequently in 1934 for reasons mentioned above the Divisional Forest Officer decided to revert to direct sowing. He also reports that the earlier the sowing is carried out (end of April) the better the percentage of germination obtained. A count showed that seed sown end of April give 60 per cent. to 70 per cent. and that sown later in May only give from 45 per cent. to 50 per cent. In addition an experiment was carried out over 5 or 6 acres, with sowing germinating seeds as recommended by the Burma Silviculturist in the above mentioned letter. Instead of using the pit method of treatment, flat places in the *jhums* were prepared by mid-April. The seed was then spread about 3 or 4" deep and watered (when it did not rain sufficiently) every other day. As soon as seeds germinated, they were pricked out and sown until the area was complete. After this any failure was replaced in the same way, the balance of the seeds being sown in a nursery for infilling as transplants in the first year and as root and shoots in the second year. A disadvantage of this method was found to be that the radicle was often broken during transport. This is purely lack of experience and it should be possible to avoid this in future.

The villagers are practised *taungya* cutters and do two years cleaning free and are paid Rs. 10 per cent. plants assessed after the 2nd year's cleanings, though a part payment of some Rs. 2-8-0 are paid at the end of the first year.

The villagers are practised *taunga* cutters and do two years cleaning dry paddy, *cotton* and *til*, with some brinjals and chillis, maize, etc., near the huts. These crops get about 2 weedings and harvesting is mainly over by November after which they free the seedlings using the *dao*, but pulling up climbers. Ordinary two or three cleanings are done in the second year and departmentally until the end of the 4th year by which time in a fully stocked plantation a complete canopy should have been formed.

First thinning is usually carried out in the 5th year and in exceptionally good areas in the fourth year after formation, and thereafter every five years. The first thinning should be as mechanical as possible, the exceptions to a pure mechanical thinning being all forked, badly cankered, misshaped and suppressed trees, which should be removed. Trees on the edge of a blank must be left. After the first thinning in a normal area the spacing of 6′ × 6′ will be changed to the diagonal 8½′ × 8½′. The second thinning will again be as mechanical as possible by the removal of trees in each alternate line, *e.g.*, 2, 4, 6, etc., reducing the spacing to 12′ × 12′. *Teak* must never be allowed to become crown-bound as it has definitely been proved that teak that has once been suppressed does not respond to a thinning for 3 or 4 years and so much increment is lost. Thinning should therefore be so done that the canopy is not completely closed until the year before the next thinning is due. In the case of teak all suppressed and dominated stems should be removed in thinnings as this species suffers from so many pests and diseases which may become epidemic ; these are usually spread from those trees that are sickly and have not got full room for their development. It is essential that the floor of a teak forest should be well covered by a fairly dense understorey, otherwise the surface soil is soon washed away and roots bared. In Bengal we are lucky in that bamboos come up over large areas and have formed quite a dense undergrowth at the end of the 5th or 6th year, provided the first thinning is heavy enough to let in sufficient light to encourage the growth of the bomboos.

The average cost per acre of teak taungya plantations in the Chittagong Hill Tracts division, Bengal.

	Rs.	A.	P.
1st year	7	0	0
2nd year	12	3	0
3rd year	4	12	0
4th year	0	11	0
5th year	0	13	0
6th year	0	11	0
7th year	1	8	0
8th year	0	7	0
9th year	0	7	0
10th year	1	1	0
11th year	1	6	0
12th year	0	6	0
13th year	0	2	0
14th year	0	3	0
15th year	*Nil.*		
16th year	1	2	0
17th year	0	1	0
18th year	0	2	0
19th year	0	9	0
20th year	0	5	0
21st year	*Nil.*		
22nd year	*Nil.*		
Total cost = Rs.	33	13	0 per acre up to the end of the 22nd year.

Report of Debate.

Mr. Ramiengar.—Before I speak on the subject, I have to state that I have been asked to deal with it at very short notice. I believe it was intended that the Coorg representative should move this subject, but he is not present on account of illness.

The raising of teak plantations has been fairly successful almost from the very commencement in all the provinces which have undertaken this work on a large scale. As a result of recent investigations, it has been proved that to ensure successful stocking of teak plantations, a good and uniform burn and the use of good stumps are essential. If these two items are carefully attended to, it can be expected that a fully stocked plantation will be easily obtained. In my opinion, there are some other small matters which require further investigation and adoption chiefly on the score of reduction in expenditure. The first point I should like to refer to, is the question of weeding of plantations. As most of you who are present here know, weeding is a laborious and expensive item in the raising of plantations. My remarks are made mainly with reference to plantations raised departmentally, *i.e.*, where all the operations are conducted on paid labour. The general practice in Mysore is to have three weedings at fairly equal intervals in the first year of the plantations, two weedings in the second year and one in the third year, when if the plantation is fully stocked it is expected that no other expenditure will be required to be incurred until thinnings are to be carried out.

The second point which probably requires investigation is the replacement of failures. In the first and second years of plantations, if, on account of soil conditions or for any other reason, there should be a failure, is it desirable that labour and time should be spent in introducing teak in the second and subsequent year of the plantation? Would it not be advantageous to encourage other growth in such places to obtain a useful mixture? I believe some useful investigation work may be carried out on these two points with a view to standardisation and reduction of expenditure.

One other question that is now pressing for solution is the introduction of teak in the so-called deciduous forests where *Dendrocalamus srictus* bamboo is prevalent. I do not think we have very much in the way of record of the effect of the small bamboo on the growth of teak plantations. In Mysore advantage was taken of bamboos seeding some years ago to introduce teak in patches by burning the bamboos but our later experience in the last 10 years has shown the enormous expense in maintaining these patches.

Mr. Laurie.—In a note that was sent in I gave a summary of the procedure in Madras in three divisions, Nilambur, Wynaad and Mount Stuart (see page 290). While conditions in these three areas vary very much, the methods adopted are really very similar. At Nilambur previously, up till about 4 or 5 years ago, plantations were almost all formed by entire transplanting but since then that method has been almost entirely dropped. It has been found unreliable. A break in the monsoon causes a very large number of failures. Subsequently direct sowing and stump planting were adopted. Direct sowing was done more than stump planting up to the last year or so but there is a tendency for stump planting to increase. Stump planting has been practised in places for a number of years now and has produced successful plantations. I can give no reason for stump planting being done in one division and direct sowing in another, but at Mount Stuart entire transplanting is quite out of the question. The monsoon is too unreliable and direct sowing was done there for many years and did not give satisfactory results. Replacements very often were as much as 100 to 130 per cent. in the first year—that is to say that the plants that were replaced had to be replaced again—and now only stump planting is done. The general tendency, therefore, in the province is to go over to stump planting.

Regarding spacing, 6′ × 6′ is adopted at Nilambur and in the Wynaad. At Mount Stuart teak growth is slow and weed conditions are very much worse than anywhere else. 4½′ × 4½′ spacing was used for many years and only recently have we gone to 6′ × 6′. In the few years that we have done 6′ × 6′ planting our experience has indicated strongly that we ought to go back to 4½′ × 4½′ espacement because in the second and third years the tending costs, creeper cuttings, etc., are so much higher that they more than counteract the extra expense of planting at the closer espacement. There are strong indications that this change will be necessary but this has only recently been realised. We did some experiments on replacements at Mount Stuart in which casualties replaced by stumps in the second year were observed and measured and it was found that a very small percentage I think 19 per cent. of the second year's replacements survived and those that did survive did not take their place in the main crop. Now in Palghat we have repeated that experiment and there the result is entirely the opposite—the percentage of survival there was over 80. So it appears that you cannot generalise. The thing has to be done according to local conditions. A great advance has been made in the last two years in the question of early stump planting of teak. In all three localities mentioned above we have conducted numerous experiments and an article appeared in the *Indian Forester* on this subject showing that stump planting of teak early in April gives the most successful results. In a normal season you can do the planting in April and you get very nearly double the height by the next hot weather. This last year has been a very good test of that. It has been a very severe hot weather. In Nilambur they planted their stumps in the first week of April and I think about 90 per cent. have failed. But they did not get any appreciable rain for a long time after planting. At Mount Stuart stumps were planted in the first two weeks of April. They got about 0.8-in. of rain on the 16th of April and thereafter only one or two very small showers in the next six weeks. The results have been excellent. It is the most successful plantation so far made there. Stocking is over 95 per cent. and the plants now average nearly 4-ft. in height 6 months after planting. I might mention that at Nilambur they planted some more plants about the 20th of April and they were very successful, so that it appears that it is quite safe even in the worst seasons to plant the stumps from the 15th to the 20th of April. At the last conference it was stated that we had had considerable difficulty in regenerating the second rotation of plantation teak at Nilambar. The chief point was that we did not get a good burn. Regrowth of weeds was very bad and the growth of the teak was so slow that there were numerous casualties. Those difficulties seem to have disappeared almost entirely. It is rather difficult to state the reason but I think it is chiefly due to improved methods of weeding and the use of stumps, and now it is actually easier and cheaper to raise a second rotation plantation than a first rotation plantation. In a second rotation plantation the saving in cost is mainly in the clear felling. There is no bamboo forest, and the clear felling costs are very low. The revenue again from selling the small wood more than counteracts any extra expenditure in formation on account of weeding which might result from the lack of burn. The burn is very poor in a second rotation plantation but we do not mind that. We have found that by intensive weeding we are able to get the plants up and they are just as well advanced as the first rotation plantations by the end of the first year. In fact on the whole rather better.

A good burn is undoubtedly very beneficial and we like to get a good burn if we can, but we find that in places where the burn has been too intense the soil has been rendered sterile in some way. After the plantation has grown for a few months you can go over it and you will find places which had had a moderate burn where the plants are very healthy indeed but in places with the poor burn and also with an excessive burn they are much worse. I think there is a good deal to be done in the way of trying to get as even a burn of the right intensity over as large a portion of the area as possible. How much expenditure will be involved in spreading over the material is a matter which will have to be gone into.

Mr. Watts.—The most important thing to do now is to put all the information together in a form available for provinces.

Mr. Champion.—This item has been treated rather unkindly in the way of covering of the ground before the conference, but with the exception of the two important States of Travancore and Mysore which I have quite recently visited and collecting the necessary full notes, we have now up to date reports from all provinces on this problem. The obvious features of the reports as a whole is one that could easily be foreseen, namely that in different parts teak plantation work necessitates different methods. I personally think it is time we had a summary because we have many instances of improvements in technique and plantation methods being developed fully, in one place and only very slowly in another.

With regard to early planting of stumps we have been told that in most of Madras perhaps, and all over Travancore, it is the best method under practically all conditions. Other areas are less favourably situated and particularly where there is a hot summer, it is risky. We find in the U. P. that probably only one year in 3 or 4 will give good results.

It therefore appears that the best step for us is to collect all the available information on these various developments, with the idea that with this information officers in any part of India can obtain useful suggestions as to methods that ought to be tried out for any particular locality. At the same time many of the points involved necessitate, for a satisfactory solution, systematic work on the best lines we have at our disposal, and ordinarily they involve repetition [illegible] years.

A great deal of teak plantation work from the experimental side is done by the divisional officer with or without the collaboration of the research officer. But research work done on these lines, valuable as it is, is liable to lead to mistaken conclusions and, therefore, I think it is most important on this subject to see that there is close co-operation between divisional officers and the research staff. It is extraordinary how custom has varied from place to place. It is also surprising how frequently plantation spacing has come to 6′ × 6′. Provinces which have done 2′ × 2′ and provinces that have started with one chain by 12 feet, all seem gradually to work back to that central figure of 6′ × 6′. Mr. Laurie mentioned the probability that in certain portions of the Madras Presidency a closer spacing would need to be considered, and he gave the ground that it is ultimately a question of cost. If we can reduce the nett cost of a plantation, by closer spacing, without any concomitant disadvantage, then obviously we ought to do it. And exactly the same thing applies to wide spacing. The usual argument advanced in favour of close spacing is that it cuts down the weeding costs and that any subsequent disadvantages can be obviated by early and extensive thinning, while wide spacing usually meets with the general objection to the shape and form of the teak. That point was investigated in the Java experiments and working with spacings such as we have, 9′ × 9′ and 12′ × 12′, they were strongly opposed even to 9′ × 9′ because it resulted in more or less fluting and bad shape of bole. It is a question which could easily be taken up by the research branches and it is one on which we in India have very little information.

The question of replacements of casualties is another interesting one. We had two examples quoted of contradictory conclusions which provided another good example of the danger of generalising from the experiments carried out in one place under one set of circumstances, particularly if it is not under the supervision of the research officer. Replacements in the current year are of course on a different footing to replacements in later years.

Mr. Homfray.—I should like to bring up the question of *taungya* labour with these different methods of sowing and planting in the first year. We have chopped and changed a lot in Bengal. Up to 1931 we did direct sowing and we gave the cultivator a certain amount of seed. The D. F. O. in 1931 thought this unnecessary expenditure and got the cultivator to take up the method of transplanting. The idea was that he felt that by putting plants in straight away he would save expense on filling on account of bad germination of seed. Experience showed as in Madras that short droughts may cause heavy casualties to the transplants. As to the question of growth, the plants that did survive were definitely much bigger than those in the direct sowing but owing to the number of in-filling the average growth of the crops was very irregular. Another point was that during the *taungya* you have only a limited amount of labour as a rule and we found that owing to the little transplanting we could not get our second and third year weeding done with the labour and these were being neglected and a lot of damage done by weeds. With the *taungya* method labour must not be completely subordinated to need of the department. Sowing can be completed by the middle of May whereas transplanting cannot be done before the end of June and that is exactly the time when the agriculturist wants to put down his paddy. Transplanting must actually be done at the only time he wants to do his own work. Therefore sowing is preferable.

Then the question of stumps ; we found that stumps put out in the first week of April have done excellently and growth for these is best. As regards spacing, with anything less than 6′ × 6′, you get the low branches formed and they seem to persist.

Mr. Smythies.—The subject of teak plantation technique in the United Provinces is very important to us because in the last ten years we have started teak plantations and we are lucky to have the experience of the other provinces to help us. The scale of the work we are doing is indicated by the fact that we get 150 maunds of seed every year from Burma, supplemented by seeds from our own plantations. We plant everywhere by stumps except in *taungya* areas. We are trying to fill up areas of *sal* by putting in teak stumps. Our spacing is always 6′ × 6′. As regards early planting we tried that on a pretty extensive scale under various conditions, and we found practically everywhere that the percentage of success was very small indeed. Although we found that the growth of those that survived was definitely better, we could not adopt this method of early planting owing to the large percentage of casualties and we have to go back everywhere to planting at the break of the rains. The conditions which we consider very important are soil and climate. We have tried teak I think in every type of soil, but now we are making teak plantations on the better quality areas only. As regards second rotation plantation, we have only one case. At Gorakhpur the second rotation plantation was entirely natural. The plants came up in millions and crowded the whole area and the growth of the second rotation crops promises to be infinitely better than the first original crops.

As regards the teak in *taungya,* our difficulty is that in two years the plants are so high that they interfere with the cultivation and everywhere the cultivators object to being turned out so soon on to a new area. The point about a good burn hardly ever arises. If we have a chance of burning we do so, but usually there is nothing to burn. One difficulty, of course, we have had. Even as far as Gorakhpur we get exceptional years of severe frost where plants up to 25 feet high die. That is liable to happen one year in 8 or 10.

Mr. Osmaston.—We plant 6′ × 6′. We have good plantations, as Mr. Champion mentioned just now of 12′ by one chain and they are growing up very well now. They are about 30 years old. But we do think that is much too far apart. That was a sort of preliminary work when the object was probably to cover a large area at as low a cost as possible. We have *taungya* in Puri, where I think the spacing is 6′ × 12′, and that, I believe, is doing well. And as to planting in the shade, there is an interesting experiment (15 months old) being carried out in Palamau. The D. F. O. wants to introduce a more valuable species into dry mixed deciduous forest of low value which is being worked under copice. So he under plants with teak stumps 18 months before the crop is due to be coppiced. So far it has been very promising and the teak has come up well in the shade of the dry mixed deciduous forests. And I hope when the crop is coppiced the teak will shoot ahead quickly and will not require the weeding that would be necessary if teak were planted after the standing crop was coppiced.

The only other interesting thing we are doing at present is in the Angul and Puri divisions. Our costs are rather high in departmental planting being about Rs. 35 per acre (including jungle clearing). When done by the *taungya* process, the cost varies from Rs. 12 to 19. So to reduce costs we have started an experiment of planting turmeric with the teak. It requires a good deal of cultivation before you plant the teak. In May to June after the burn the ground is ploughed 3 or 4 times before the turmeric is sown. At the break of the rains the teak is put in. The turmeric then grows up and reaches a height of 2½ feet by November, when it dies down. It resprouts in the succeeding rains, and is harvested in March of the second year. The approximate cost is about Rs. 60 an acre in the first year. Including the second year the total cost of formation will be 75 to 80 rupees. It is hoped we shall then get a revenue of Rs. 100 an acre so there should be a profit if all goes well.

Mr. Garland.—Our experience in Bombay corresponds closely to that of Madras. Stump planting is becoming more and more general. But I do want to bring up one point in connection with the preliminary burning. It seems that the soil scientists are still not agreed as to the precise action of such partial sterilisation of the soil. It is, however, generally conceded that soils which in a great variety of organic constituents respond best to such treatment. This has certainly been our experience. In Kanara where climatic conditions result in a climax forest of evergreen type, the results are excellent. But in drier areas we are not absolutely satisfied that this is the best possible method. It is expensive and the suggestion has been made that the ordinary practice of the agriculturist may be significant in this connection. In areas where one burning is completely successful the farmer in adjacent fields invariably prepares his seed bed for his crops in exactly the same way by burning brushwood. But in the dry areas he has developed an entirely different technique. There he ploughs as early as possible, *i.e.*, in December and January and leaves the clods to the action of sun and air, which appears sufficient to restore fertility. Burning of brushwood is not practised even where ample is available.

ITEM 25.

Record of Fire Protection Results.

The subject was considered at the instance of the Inspector-General of Forests owing to the feeling in some provinces that in view of the extended use of departmental controlled burning, the current figures given when reporting the success of fire protection measures were liable to be misleading.

Mr. *E. A. Smythies* (United Provinces) summarised the reports from all provinces and proposed the following resolution which was seconded by Mr. *H. L. Wright*, and passed after a short discussion.

RESOLUTION ON ITEM 25.

RESOLVED *that*—

The Inspector-General of Forests be asked to approach the Government of India to allow provinces to modify Code Form 14 and record the results of fire protection as they consider most suitable for local conditions, provided that the information required by the Inspector-General of Forests for Statement VIII of the Annual Return of Statistics relating to Forest Administration in British India is given clearly and concisely.

Summary note by E. A. Smythies, Conservator, Western Circle, United Provinces.

The Chief Conservator of Forests, U. P., in 1933 suggested to the Inspector-General of Forests that Code form 14 dealing with fire protection should be modified to the extent of splitting up each column into two to separate out :—

(*i*) areas departmentally burnt as a form of insurance against worse damage,

(*ii*) areas completely protected.

The Inspector-General of Forests sent the proposal to all Provinces for opinion, and the answers received indicate that all provinces, except Punjab and Central Provinces, were neutral or in favour.

The Chief Conservator of Forests, Punjab, replied " Both the Conservators and I are not in favour of the proposal. We do not consider that the proposed division will give figures of any use or interest. I am not sure what the object of the Chief Conservator of Forests, U. P. is in making the suggestion."

The Chief Conservator of Forests, Central Provinces, pointed out that all forests were divided into 3 classes :—

Class I.—Completely protected, with fire-lines, guide lines and patrols.

Class II.—Partially protected, by burning along fire lines, roads, ridges, grassy maidans in successive stages and allowing the fire to burn itself out. Normally no firewatchers.

Class III.—Protected by law, but not in practice.

He thought the proposed sub-division of Code form 14 into " Areas burnt under control " and " Areas protected by other means " was not suitable for conditions in the Central Provinces, and suggested sub-division into " Areas completely protected " and "Areas generally protected ".

When replies from Provinces had been received, the Inspector-General of Forests asked that the opinion of the Silvicultural Conference should be taken on the matter. The Conference has therefore to come to some decision, should Code Form No. 14 be altered and, if so, how ?

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